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Science Education

Devoted to the Teaching of Science in Elementary Schools, Junior and Senior High Schools, Colleges and Teacher Training Institutions

Volume 16 DECEMBER, 1932 Number 6

Aptitude and Its Relation to Achievement in General Chemistry

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There is a difference of opinion as to the value of aptitude examinations. There are those who feel that aptitude in a given field is a function far too complex to permit of measurement by any single test. There are others who hold that, while aptitude is a complex function, its most essential elements may be measured by comparatively simple tests. It is not the purpose of the present paper to enter into a discussion of the question raised. Aptitude examinations are being widely used and are being found useful. There seems to be no doubt that such tests as the Iowa Aptitude Tests do measure something which functions in the learning process. The author has found this to be true of the Iowa Chemistry Aptitude Test developed by G. D. Stoddard and J. Cornog as one of the "Iowa Placement Examinations" in the series devised by C. E. Seashore and G. M. Ruch, and published under the auspices of the University of Iowa. Regardless of whether it measures adequately all of the abilities that function in the study of chemistry, it has been found useful in predicting the probable success of students in this subject, as well as furnishing a basis for sectioning of classes.

Bird[1] found, from his study of students in the North Dakota State

College, that the Iowa Chemistry Aptitude Test provides a satisfactory basis for sectioning of classes in general chemistry. Similar observations have been made by other institutions. The author has used this test as an instrument for diagnosing individual learning difficulties of students in the study of chemistry.

The Chemistry Aptitude Test is so constructed that the first part gives the instructor an opportunity to study the individual difficulties of students in applying some simple mathematical concepts in the field of chemistry. Students who are found to be deficient in any mathematical concept that is essential to the proper mastery of general chemistry can be given special consideration by the instructor. It is useless for the chemistry instructor to lament the inferior instruction which the student may have received on the elementary- or secondary-school level. If the college accepts the student it should undertake to do everything possible to assist him to realize his highest possibilities. It is true in many cases that a mathematical concept does not function in a chemical situation simply because it has not been so conditioned as to cause it to function. The instructor's task, then, is to take that concept and, by the skillful application of the concept to chemical situations, so condition the reactions involving that concept that the student can use it in the new field.

Part two of this test is a chemistry reading test which is designed to measure the ability of the student to read simple expositive chemical literature. This reading test, while not as complete nor as thorough as those described by Bray,[2] is valuable for diagnostic purposes. Many students who take this test are surprised to discover that they have more or less serious reading difficulties. They learn, for the first time, that their trouble in studying chemistry is a reading disability. Some read rapidly but so inaccurately that their reactions to the material read are far from satisfactory. Others read with reasonable accuracy but so slowly that the adequate preparation of a given assignment is an almost impossible task. Both of these cases, as well as others, can be discovered by this test if the instructor cares to do so.

The college may not be in a position to do for the student with reading disabilities what is being done at Ohio State University under the direction of Pressey and Pressey.[3] Even if the college is not in a position to render such assistance, the individual student, when the disability has been called to his attention, will often set about to discover for himself ways of correcting the difficulty.

Part four of this test is designed to measure the student's information in the general field of science. Many students, as discovered by this test, have had such limited experience with the various fields of science that

there is a definite handicap in the study of chemistry. Their reading has been almost exclusively in fields other than science and their election of science courses in high school has been limited. Such students generally have more difficulty in mastering chemistry in college than those who have a reasonable knowledge of facts in the field of science in general.

It would seem that, if the instructor can not make definite plans to meet and correct the individual disabilities detected, it would be to the advantage of both the student and the teacher if such disabilities were discovered in advance, pointed out, and kept in mind. The author's experience with this test as a diagnostic instrument has proved to be satisfactory.

The present study involves two hundred students of first-quarter, general chemistry in two Missouri state teachers colleges during the school years 1928-1930. The Iowa Chemistry Aptitude Test was given at the beginning of the quarter session (12 weeks). Near the end of the quarter session the achievement of the group was measured by means of the Iowa Chemistry Training Test, Form B. Table I gives a summary of the results obtained from these two tests.

Table I
Summary of Data from Iowa Chemistry Aptitude and Iowa Chemistry Training Tests

Measures	*Aptitude Test*	*Training Test*
Median	39.45	52.2
Mean	42.9	62.8
Q_1	30.2	44.0
Q_3	52.7	80.8
Q	11.3	18.3
S.D. (Sigma)	17.15	26.15
No. of cases	200	191

A study of Table I shows that the mean score on the Aptitude Test is 42.9. About 68 per cent of the scores would most probably fall between 26 and 60. The mean of the Chemistry Training Test scores is 62.8. The mean of the scores on the same test as found by Bray in his study of a similar student group was 63.1, while the S.D. of his group was 26.97.[4] When Chemistry Aptitude is plotted against the final achievement in the course, as measured by the Training Test, the curve obtained is very similar to that shown by Bird.[5] About 68 per cent of the scores on the training Test would most probably fall between 37 and 89.

It was found that 34.6 per cent of the group who were below the 25 percentile point (Q_1) on the Aptitude Test were also below Q_1 on the Training Test at the end of the term. It was also found that 42.2 per cent

of those who were above the 75 percentile point (Q_3) on the Aptitude Test were also above Q_3 on the Training Test.

It was discovered that 6.25 per cent of those who were below Q_1 on the Aptitude Test scored above Q_3 on the Training Test at the end of the term, while 42.9 per cent of this group scored above the median on the Training Test. None of those who scored above Q_3 on the Aptitude Test scored below the median on the Training Test.

A study of the results indicated above would seem to show that the Iowa Chemistry Aptitude Test is a fairly accurate instrument for predicting the success of superior students. If a student scores high on this test at the beginning of the term it is almost certain that, assuming normal effort on the part of the student, he will score above the median on the Chemistry Training Test at the end of the quarter session. On the other hand, it is far from certain that the student who scores low on the Aptitude Test will score low on the Training Test. There are many other factors involved that are not measured by the Aptitude Test to permit of accurate prediction of the achievement of those who score low on this test. Among these may be mentioned the capacity and willingness of the student to put forth sustained effort, attitude toward the work, extra-curricular activities in which the student is engaged, and the ability of the teacher to stimulate the inferior student.

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[1] Bird, Kenneth L. "The Use of an Aptitude Test As a Basis for Sectioning Freshman College Chemistry Students." *Journal of Chemical Education* 7:1118-1121; May, 1930.

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[3] Pressey, L. C. and Pressey, L. S. "Training College Freshmen to Read." *Journal of Educational Research* 21:203; 1930.

[4] Bray, Willis J., *op. cit.* p. 49.

[5] Bird, Kenneth L., *op. cit.* p. 1121.

Variation in Method of Teaching General Science*

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If there is one single thing at which human nature rebels most, it is monotony. This rebellion causes changes of styles in buildings, in house furnishings, in cars, in clothes; it causes new methods of preparing foods; it makes vacations imperative. We have ceased to think of vacations altogether as a respite from work, but rather as a change in surroundings. Wherever the locality is chosen we see trees, and water, and earth, and folks, but they satisfy because we feel a new experience in observing old things in a different setting. We have stopped learning largely when our craving for new experiences ceases. When we have failed to provide pupils with a variety of activities, whereby they may observe and find a means for their own self-expression, we have stopped no considerable part of their learning. We used to hear much of discipline—the old pin-drop kind —because we thought if the child didn't listen he couldn't learn. Now we are changing the word "listening" to "attending," and quietness may or may not be a part of the necessary attention.

All of the senses were given us as contact avenues, yet, as teachers, we still depend too much on hearing. It was said of President Coolidge that during his administration he rested our ear drums. As I go from room to room, I often think how great the relief would be if we could only do that, at least occasionally, for our classes. The high challenge of facing 30 to 40 boys and girls of junior-high-school age should stimulate something better in preparation on the teacher's part than the too frequent oral inquisition. The 30 to 40 will be there ready and expectant—what are we going to do about it?

It is not that we do not know how to proceed, but that we fail to make the drive for sufficient preparation. No one knows better than the science teacher what that drive has to be. The care and setting-up of apparatus, the operation of lanterns and moving-picture machines, the planning of field trips, the drawing of illustrations, the gathering of reference lists, the delving into what for many is entirely new subject matter, makes

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* Presented at the General Science Section of the Sixth District M.E.A. Detroit, Michigan, Oct. 17, 1931.

an appalling amount of work, especially for the new teacher. But there are no easy tasks in the teaching profession, and none pays more in sheer enjoyment than that of general science. The methods enumerated here are not new, but merely an elaboration of some that science teachers probably already know. Sometimes it is as valuable to have the old brought back into consciousness as to strive for the new. It is a change, a variation, a difference in our day-to-day method for which we must strive—not the project plan, nor the contract plan, nor the socialized recitation plan, nor any one plan, however unique it may be. In any method, economy of time for both pupil and teacher must be taken into account. When the point of diminishing returns has been reached for either or both, a change is necessary. All changes do not mean progress, but in order to progress very far a change is necessary. The following methods—and there are many others—presuppose the unit plan of instruction. Large units may be broken into smaller problems each with a stated aim, applicable devices which consist of both teacher and pupil activities, the textbook and library references, and the pupil outcomes. By "outcomes" are meant the changes which we hope will occur in the pupils' thinking as the result of working out the problem. The teacher's final preparation consists in fitting a method to the problem which will insure the largest possible returns in desirable outcomes.

In large classes it is next to impossible for junior-high-school pupils to do individual laboratory work, but pupils, if not capable of carrying out the demonstration alone, may take turns as assistants to the instructor. Pupils, as well as teachers, often need to see the lesson pattern in advance. Try writing the aim on the board as a part of the assignment, and ask for suggestions as to devices. Recently, I saw a small eighth-grade student walk over to the desk, pick up a 500 gram weight, and proceed to demonstrate stability and instability of objects, as well as inertia, all with the same object. This was a simple way to illustrate a principle, but the instructor had not thought of it before. The better classes, of course, are more prolific in ideas, but no group is utterly barren. They enjoy finding an illustration that works well enough to meet the approval of the group. Whatever illustrative material is used, however, should be tabulated under the principle it illustrates. Many will remember the illustration, especially if it be at all spectacular, but promptly forget the principle involved. For example, a class was to attend a given lecture and report back to the group, by means of notes, the gist of the discussion. An illustration, although the pupil had not the slightest idea of its application, concerned the fact that there were many women teaching school who might be employed to better advantage in chicken raising. That was the headline of the

pupil's report, and the teacher was a woman. It did not prove satisfactory. If a demonstration is of sufficient length and can be called an experiment, it should have a certain formal write-up. If it is a simple illustration, it is set down in the pupil's notebook under the principle it illustrates. If reports on demonstrations are not written the demonstrations become mere entertainment.

Field trips, unlimited in scope, either as to territory or specimens, become a hodge podge. A definite outline is necessary for a report. The idea of education as that of a pupil on one end of a log and a teacher on the other may have presupposed all out of doors as subject-matter and thus the entire course became a field trip. However, we have to plan for the outcome of not only one child, but the 30 to 40, and because we feel there are too many to look after, or that our territory is so limited there is nothing to see, we never venture forth.

The earth does not provide the only source for such trips. Clouds, sun spots, thunder-storms, and other heavenly phenomena can be the basis for field trips, even from inside the school room, if desired. Several teachers whom I know mount a small telescope in the school yard on clear evenings, and not only pupils, but parents come in to see the marvels revealed. Do not stop teaching constellations when the unit on astronomy is finished; take a few minutes off from the other units to chart the new figures as they appear in the heavens throughout the year.

However important field trips may become in our daily scheme of things, we must depend very greatly on the experiences gained from the printed page. "Ability to read well is doubtless the most important single tool in the junior- and senior-high school." If silent reading is to be another method of thinking, three factors must be considered: first, proper pronunciation of the word; second, interpretation of the word; and third, interpretation of the sentence. Other skills, such as finding the material, skimming and summarizing would seem to be contributory to these three essentials. There are as many different kinds of readers as there are pupils, and each case is individual. However, there are some errors common enough to be attacked by an entire class. Judd and Buswell in their monograph on silent reading say that the ordinary textbook was not meant to be read, but to be analyzed. A few minutes each day might be spent profitably in helping pupils to interpret such devices as splitting the paragraph into smaller parts, choosing guide-post sentences, skimming in order to find answers to the teacher's questions or making questions of their own over the assignment. Recently a regular general-science teacher was needed elsewhere in the building during the class hour. The subject of rocks was more than on the rocks—it was buried for all the pupils seemed to care.

The introductory remark of the supply teacher was to the effect that a certain paragraph contained the names of three kinds of rocks and how they were made, and she would like to determine the length of time it would take each pupil to get the information. Hands were to be raised as soon as the answers were all found. They were interested and burrowed in, making notes as they read. Puzzled frowns appeared here and there and the supply teacher was on the alert noting the speed with which the individuals seemed to run into difficulty. After re-reading the paragraph, hands were raised and someone blurted out that there were not three kinds of rocks mentioned in that paragraph, but only two. In the meantime, however, someone had done more than he had been told to do and read on a bit further to find the additional information. The new teacher had been wrong just enough for the class to enjoy a discovery of the error and for her almost at once to detect some of the fastest as well as some of the slowest readers. If we watch for the speed of reading, the speed of getting the thought, and for those pupils who merely pronounce words, we shall be able soon, partially at least, to sort out according to ability. One great difficulty seems to be in finding a suitable textbook for the low groups of the seventh grade; books on a fifth or sixth grade level for the slower readers should be provided. We cannot hope to teach all pupils from the same books. The faster reader will, of course, read more difficult material and in greater quantity than the slower pupil, but reading material must be provided of such character that the slow reader will make contacts with the work in hand.

Science should be secondary only to English in supplying terms for expression. Every child in junior high school, regardless of his mental ability, should be obliged to learn at least enough scientific words to substitute for the vulgarity which is all too common, merely because the correct term is unknown. The definition of dirt as matter out of place applies to the mental as well as to the physical state. Sometimes it is easy to learn these new words as we demonstrate. Take the time to write a new word on the board when it appears in connection with an experiment, and note the comparative ease of assimilation. Use every available visual aid of charts, maps, blackboard drawings and book illustrations, but remember that too many words at one time degenerate into definitions which bore rather than stimulate. A quick spell-down involving definitions is a good review.

From analyzing the text to locating reference material in the library is but a step. Some assignments lend themselves admirably to the committee plan of attack. Librarians are always ready to coöperate in helping to find references and illustrative supplies for group work. These supplies

may be brought into the classroom and arranged in piles according to the topic. Each committee under the leadership of a chairman may assemble all available information about the assigned topic which is later reported to the group as a whole. The ability to boil down and deliver a good report is an art in itself in addition to the ability of collecting data for such a report.

But probably the greatest joy comes in learning to read science books for pleasure. Occasionally, the library charts can be filled with the science books and taken into a classroom where the boys and girls are allowed to spend an hour in browsing. If the library is available the entire class may go there for the same purpose. Teachers may keep several books on their desks, and whenever there is an odd moment, a few interesting pages may be read aloud with information as to the title and author in case some one wants to read further. The librarian in one building where these devices were tried reported that the number of science books in circulation exceeded that of any other department, English included. Browsing days for the various science groups had to be spread over a considerable period of time because the books were practically all withdrawn immediately following the period in the library, leaving none for the next class. Certainly, such time was not wasted.

To summarize briefly, the common methods suggested are those concerned with the laboratory or experimental part of general science involving both teacher and pupil participation; the illustration method, where pupils help to discover devices as illustrative material and keep a record of the principle along with the illustration; the field trip, which has a definite plan both as to the trip itself and the report to the instructor or to the class as a whole; the committee plan of attack through group work from library supplies; the silent-reading method through helping to learn new words and through providing reading material on the level of capacity; the stimulation for reading scientific books and magazines through browsing days in classrooms or libraries.

Report of the Committee on the Judging of Science Essays

G. M. RUCH AND P. M. SYMONDS

I. Introductory Statement

During 1930-1931 the Executive Committee of the Committee on the Place of Science in Education of the American Association for the Advancement of Science announced a plan for a nation-wide competition among high school students in the writing of science essays.*

The plan of the competition was briefly as follows: Students of junior- and senior-high-school classification might select a topic from a list of forty-four circulated by the committee or they might submit other topics for the approval of the committee. No limitation upon the length of the essays was imposed but it was suggested that "between fifteen and thirty typed pages" would be proper. The conditions of the contest further stated that "the facts and thought set forth and the style of presentation were expected to provide reliable and engaging 'good reading' for intelligent people."

Twenty cash prizes were awarded, ranging from $200 for the essay judged best to $50 each for essays ranking from fifteenth to twentieth in merit, a total of $1800. The money received as awards, it was stipulated, was to be spent for books for the enrichment of the school library, such books to be credited as contributions by the pupils who won prizes with their essays. The funds for prizes and for the expenses of the committee had been provided by six persons especially interested in improving secondary education and in giving added opportunities to superior pupils.

The closing date for the submission of essays was March 15, 1931.

II. The Method of Judging the Essays

The published plan of the contest provided that the Committee on the Place of Science in Education should appoint a committee of readers and judges. Dr. Otis W. Caldwell of the Institute of School Experimentation, Co-

* The essays that were submitted to the American Association for the Advancement of Science Committee on the Place of Science in Education, were judged by a special committee, according to a method designed for this specific purpose. The plans for the essays,[a] and the results of the contest,[b] have been published by the American Association for the Advancement of Science Committee. This report of procedures in judging the essays, while prepared by those named as authors, represents work done by the whole judging committee.

[a] *School and Society* 31:1-4; March 22, 1930.

[b] *Science* 75:385-388; April 8, 1932, pp. 385-388.

lumbia University, as chairman of the Committee on the Place of Science in Education, organized the Judging Committee and advised it throughout regarding its procedures. The method of procedure was approved by the Committee of which he was chairman. The personnel of the Judging Committee follows: M. F. Carpenter, Iowa City, Iowa; Claudia E. Crumpton, Detroit, Michigan; Newton B. Hammond, Yonkers, New York; R. L. Lyman, Chicago, Illinois; G. M. Ruch, Berkeley, California (Chairman); Percival M. Symonds, New York City; and Lucy A. Terrell, Cleveland, Ohio. The Judging Committee met in Detroit on February 22, 1931, and drew up a plan for evaluating the essays submitted. The method agreed upon is described at some length here as it may be of value to others in judging essays written upon a variety of topics by pupils who have worked in different ways.

Standards of Excellence for Judging Science Essays

		Points
I.	Reliability of science content	25
II.	Wisdom of selection of content for essay purposes	25
III.	Intelligent adaptation of treatment to lay readers	25
IV.	Suitable organization and development of thought as a well-rounded composition	15
V.	Accuracy of language, grammar, spelling, etc.	10
	Total	100

The "Standards" adopted were at no time regarded as an exact quantitative rating scale but were rather a general working guide, with shifting foci of emphasis throughout the three-step judging procedure next to be described.

Step 1. According to the outline of the plan, all essays submitted in the contest were to be given a preliminary reading by (a) two English teachers and (b) two science teachers. In this way essays distinctly faulty in language expression or inaccurate and misleading in scientific content were to be eliminated at the outset. (Because of the limitations of time and money the preliminary reading was actually done by *one* English and *one* science teacher.)

The preliminary readings were done by the 5-pile method so as to yield a roughly normal distribution of the essays, thus:

Pile	1	2	3	4	5
Per cent	10	20	40	20	10

At this stage in the procedure Dr. P. M. Symonds of the Judging Committee made a study of the essays to determine whether the grouping by the two preceding readers seemed accurate and just. Then all papers by *any* reader in piles one and two were retained. The others, approximately one-half of the total, were not given further consideration. This lightened the

cost and labor of the final judging very greatly, and at the same time eliminated the danger of overlooking any essay of outstanding merit.

Step 2. The papers surviving the first step were then divided into subject-matter categories, *viz.*, physics, chemistry, biology, earth science, etc. Those falling into a given category were read by a reputable scientist, recognized as an authority in that particular field. Any essay that was found to contain important inaccuracies in scientific content were eliminated at this reading. It is to be noted that from this point on in the selection process scientific accuracy was assumed to have been proved, and was not further considered.

Step 3. This represented the final reading and all but one of the seven members of the Judging Committee read each of the papers that had survived "Step 2." The first point, reliability of science content, in the original "Standards of Excellence" having been provided for as already noted, each essay remaining at this point was rated from 1 to 5 on the remaining four standards by each reader. The final readers agreed to use the 1 to 5 points in a relative manner, disregarding the fact that all essays at this stage might be of high merit. This was equivalent to insisting that the five degrees of the scale be used in somewhat equal numbers. Since four criteria remained and the rating upon each might fall from one to five, the minimum rating by one judge on a given essay could be as small as four or as large as twenty. This guaranteed a distributed series of merit points. With seven judges the theoretical range of points was, therefore, from 28 to 140.

The final rating was the sum of all the independent judgments. All tie scores that occurred were within given prize groups, and since those making these tie scores received the same amounts of prize money, no recalculations were made in the case of ties.

III. The Awards

The number at the beginning of each item refers to rank; the number in parentheses is the essay number. Listing is according to groups.

Group I

1. Jane B. Sill and Edward H. Reisner, The Lincoln School of Teachers College, New York City—*Rats vs. Polyneuritis* (2); $200.

Group II

2. Daniel Eisler, 8920 Parmelee Ave., Cleveland, Ohio—*My Scientific Experiments—Why I Made Them—What I Gained from Them* (85); $150.
3. Ralph Lawrence, The Lewis & Clark High School, Spokane, Washington—*The Importance of the Protozoa and My Observations of Them* (94); $150.
4. Lincoln School Chemistry Class, Winston Hurd, Chairman, Ernest Landsteiner, Frederick Forsch, Kim Plockman, John Steinman, Eugene Williams, Jane Winternitz, The Lincoln School of Teachers College, New York City—*Crystals and Crystallization* (15); $150.

GROUP III

5. Byrne C. Manson, John Muir Tech. High School, Pasadena, California—*The Water Supplies of Ancient and Modern Peoples* (3); $100.

6. Dunbar Triplett, Jr., The Lewis & Clark High School, Spokane, Washington—*My Experiments with the Hydra* (93); $100.

7. William Stewart, Beverly Hills High School, Beverly Hills, California—*A Home in Crude Petroleum* (101); $100.

8. Katharine Marie Hall, University High School, Ann Arbor, Michigan—*The Life and Inventions of Thomas Alva Edison* (17); $100.

GROUP IV

9. John Winslow French, Pawling, New York—*The Study of Rats and Mice* (33); $75.

10. Virgil Bolen, Academy of the Western Illinois State Teachers College, Macomb, Ill.—*What Modern Science Means to Me and My Community* (89); $75.

11. Rose Auerbach, Washington Irving High School, New York City—*How Science Has Helped Man Overcome His Limitations* (100); $75.

12. Robert Ray, University High School, Oakland, California—*A Hero of Science—Dr. Jacques Loeb* (103); $75.

13. David Putnam, High School, Keene, N.H.—*Inventions in Astronomy* (102); $75.

14. Jean Elizabeth Boling, Shortridge High School, Indianapolis, Ind.—*How Has Science Changed My Daily Life?* (12); $75.

GROUP V

15. Matilda Diorio, South Philadelphia High School for Girls, Philadelphia, Pa.—*The Relation of Science to the Art of Music* (45); $50.

16. John Alloways, Central High School, Kalamazoo, Michigan—*Rayon* (5); $50.

17. Freda Becker, South Philadelphia High School for Girls, Philadelphia, Pa.—*Science and the Home* (44); $50.

18. Omer Widmoyer, Central High School, Kalamazoo, Mich.—*Cellulose and Rayon* (6); $50.

19. Wade Allen, Central High School, Kalamazoo, Mich.—*Products of the Electric Furnace* (9); $50.

20. B. Richman, Lyndhurst High School, Lyndhurst, N.J.—*Radium and Its Uses* (95); $50.

Total awards, $1800.

In addition to the library prizes, each winning pupil received a copy of Wells' and Huxley's "The Science of Life," and a page of autographs by past presidents of the American Association for the Advancement of Science.

IV. Comments on the Method of Judging and Acknowledgments

This report has been prepared at the insistence of educators who have felt that it would have value in the guidance of those undertaking similar projects. It is to be hoped that this will prove to be true. The task was no easy one and required much more time for its completion than was anticipated. An obligation to pupils and schools was incurred by those making the selections, and at every stage of the elimination and selection process the judges were conscious of the duty of meeting this obligation by striving for impersonal and objective methods. When these were impossible, recourse

was had to consensus of competent opinion in the fields of science and language expression. The original plans, as might be expected, underwent some changes when actually applied. The defects which remained are partly those inherent in the subjectivity of judgments, limited funds, and wide geographical separation of the committee members. It is further to be expected that the committee's standards and criteria reflects its personal biases in greater or less degree. In spite of these limitations, the Judging Committee completed its task with the feeling that no essay of great merit was overlooked and that the final order of the awards must represent a high degree of approximation to the evaluations at which a second and independent committee would arrive. Such a procedure seems to give the only possible measure of validity of judgments in similar undertakings.

Study Outlines in Physics—Construction and Experimental Evaluation*

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Introduction

Many science teachers may be surprised but all will be glad to learn that we may develop real interest in physics and create problem-seeking and problem-solving attitudes without lowering our standard of scholastic achievement. The simple device known as the *Study Outline,* used in the present investigation, is one means of accomplishing superior results in all of these respects: factual learning, broad conceptual learning, interest, effective study habits, problem-seeking and problem-solving attitudes, and other desirable mental habits and attitudes. This conclusion is the result of a carefully controlled experiment in teaching, carried on throughout a complete semester and involving about 850 physics pupils under 17 teachers in nine high schools of Los Angeles, California.†

Construction of Study Outlines

The *Study Outlines* consist of mimeographed assignment sheets covering the whole physics course. They are unique in that they combine the use of direct questions with the outline idea. The questions themselves are arranged in outline forms so as to show their relationship to each other and to the subject as a whole. Thus the *Study Outlines* attempt to apply the laws of learning to gain interest and mind set through carefully selected, challenging questions and to provide for better learning by revealing the association or "belongingness" of ideas. In fact, the preparation of the *Study Outlines* was based upon a thorough survey and compilation of the objectives of high-school physics teaching‡ and of the means of applying the laws of learning to achieve these objectives.

In the practical construction of the *Study Outlines,* the subject matter of physics was grouped into eight units roughly following the general or-

* Read before the National Association for Research in Science Teaching, Washington, D.C., February 23, 1932.

† The experiment is reported in detail in a dissertation for the doctorate entitled, *Study Outlines in Physics—Construction and Experimental Evaluation,* by Jessie Williams Clemensen, being published by Bureau of Publications, Teachers College, Columbia University.

‡ The complete list of general and specific objectives is included in the dissertation mentioned in the previous footnote.

ganization employed in most texts. Each unit was then divided into "problems" which embodied the large concepts of the unit. These concepts were built up step by step by means of the sub-questions in each problem. Every problem was followed by a list of references to several texts in the hope of developing in pupils the attitude of studying a problem or topic and not memorizing a textbook. The following is a sample of *Study Outline* problems. This one is taken from the unit on "Physical Properties and Behavior of Liquids."

PROBLEM 6. (Buoyancy) Under what conditions will anything float?
a. Why can a steel ship weighing thousands of tons float?
b. Does a ship float higher in salt water or fresh water? Why?
c. Even though a body does not float, is it buoyed up any (i.e. apparently made lighter) by being submerged in a liquid? Have you ever lifted a stone under water? Was it easier or more difficult than in air? Why?
d. What determines the amount by which a body will be buoyed up by a liquid? How many things count? Why?
e. What is meant by the "specific gravity" of a liquid? How is this commonly used? How is it measured?
References: (These are given by page and section for several common texts.)

The Teaching Experiment

Three types of groups were used in this investigation. Each of the experimental teachers taught two classes paired pupil-by-pupil on the basis of a battery of preliminary tests. (A regression equation and predicted scores were worked out for this purpose.) These paired groups were taught by each teacher as nearly in the same manner as is humanly possible, with the exception that one class of each pair used the *Study Outlines* for assignment sheets. The combined classes using the *Outlines* constituted the "Outline" group, while their paired controls were termed the "Non-Outline" group. For further comparison an entirely separate set of classes was used, known as the "Outside Control" group. These classes were taught in the usual manner by teachers who knew nothing whatever of the *Study Outlines*. This group was simply given the tests. It was equated with the "Outline" and the "Non-Outline" groups on the basis of the same preliminary tests.

During the last three days of the experimental semester all classes were given three types of final measures each of which required about thirty-five minutes. These measures were: first, a standard new-type objective test in high-school physics; second, a final essay test covering the whole course; and third, a questionnaire on specific habits and attitudes. Besides these, smaller topic essays were required of the "Outline" and "Non-Outline" groups during the semester, which gave interesting and valuable results. Also, both teachers and pupils filled out a questionnaire which, in a rather subtle way, revealed their attitudes toward the *Study Outlines* themselves, and indicated the extent to which they had really used them.

TABLE I
SUMMARY OF OBJECTIVE TEST DATA

Group	Number of Cases		Score	Outline Group		Non-Outline Group		Difference of Means	St. Deviation of difference of Means	Difference $+\sigma$ diff
	Outline Group	Non-Outline Group		Mean M_o	Standard deviation σ_o	Mean $M_{n.o.}$	Standard deviation $\sigma_{n.o.}$	$d = M_o - M_{n.o.}$	σd	$\frac{d}{\sigma d}$
(1)	(2)		(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Total First-Semester	49	49	(P) (F) (F-P)	31.56 33.80 +2.24	3.10 5.66	31.68 31.35 − .33	2.57 6.23	+2.57	.70	3.67
Total Second-Semester	69	69	(P) (F) (F-P)	31.60 32.58 + .98	4.54 5.80	32.48 30.20 −2.28	4.37 5.60	+3.26	.53	6.15
Second Semester unselected	92	92	(P) (F) (F-P)	32.60 32.32 − .28	4.65 6.34	32.40 30.82 −1.58	4.48 5.80	+1.30	.49	2.65
Second Semester Outline (selected) vs. Outside Control	69	115	(P) (F) (F-P)	31.60 32.58 + .98	4.54 5.80	32.88 29.08 −3.80	4.38 7.21	+4.78	.954*	5.010*
Second Semester Outline (unselected) vs. Outside Control	92	115	(P) (F) (F-P)	32.60 32.32 − .28	4.85 6.34	32.88 29.08 −3.80	4.38 7.21	+3.52	.942*	3.745*

(P) Predicted (F) Final Test (F-P) Difference
* Obtained by short, uncorrected formula; hence values too small here.

Findings and Conclusions

The entire consistency of all results of the experiment is unusually strong evidence that the *Study Outlines* produced real and measurable differences. The objective tests revealed the superiority of every one of the small "Outline" groups over its paired "Non-Outline" group of the same teacher. Even greater differences than these were shown between the "Outline" group and the "Outside Control" group. The summary of the data for the large groups only is reproduced in Table I. It should be noted that in column 8 of the table, all the differences are positive, that is, in favor of the "Outline" group.

The significance of the differences is represented by the ratio of each difference to its own standard deviation. (See Table I, column 10). A ratio of 2.405, the lowest obtained, implies more than 98 chances in 100 that the difference is not due to accidents of sampling, while a ratio of 3.9 implies 9999 chances in 10,000. Remembering this, the results obtained make it practically inconceivable that a real difference did not exist in favor of the "Outline" groups and that if the experiment were repeated under similar conditions the "Outline" groups would again show a superiority.

The essay tests revealed even more striking differences of another type. These tests were made general in nature in order to ascertain what came into the pupil's mind on the suggestion of a topic, just enough being stated in the question to prevent his rambling over too wide a field. For example, one topic-essay used during the semester was: "Tell all you can in fifteen minutes about atmospheric pressure—experiments concerning it, applications, etc." Four sets of such test papers were laboriously analyzed for concepts expressed. The method used was similar to that used by Black.[1] Each statement on each paper was copied on a card. The cards were then sorted and classified according to the types of ideas expressed. The results showed the following tendencies consistently:

1. The "Outline" groups made a greater total number of statements, i.e., had more ideas associated with the topic.
2. They attempted to explain nearly twice as large a percentage of their statements as did the "Non-Outline groups, i.e., they seemed to feel that some causal explanation was needed for nearly 70 per cent of their statements.
3. Of the explanations attempted, the percentage of scientific, causal ones was two and one-half times as great for the "Outline" groups as for their controls.
4. The "Outline" groups made a smaller percentage of incomplete, vague, and erroneous statements.
5. They made more statements which indicated a grasp of larger generalizations.
6. They also made three times as many unusual and non-text references as the "Non-Outline" groups.
7. The "Non-Outline" groups made a larger percentage of statements of minor details and isolated facts, showing that they did not have the grasp of the relative value of ideas and their relation to the topic which the "Outline" groups showed.

TABLE II
FINAL ESSAY TEST DATA
Total Number of Statements of Various Types in Final Essay Tests for "Outline," "Non-Outline," and "Outside Control Groups"
(On a basis of 30 papers for each group)

Type of Statement	Total Number of Statements					
	Outline Group Teachers F and G.		Non-Outline Group Teachers F and G.		Outside Control Group Teachers J.K.M and N.	
	No.	Per cent of Total	No.	Per cent of Total	No.	Per cent of Total
Principles						
1. Clear and complete	254		172		103	
7. Total	307	29.5	235	29.7	148	30.3
Explanations						
8. Scientific-cause and effect	35		10		15	
9. Cause-effect, incomplete	10		4		3	
13. Total	147	14.1	50	6.3	49	10.0
Illustrations, Applications						
14. Clear-connected to topic	123		60		45	
19. Total	212	20.4	183	23.2	107	21.9
Mere Statements of Fact						
20. Correct	315		240		142	
25. Total statements of fact	375	36.0	321	40.8	185	37.8
Summary						
26. Total no. clear, complete statements (Items 1, 8, 10, 14, 18, 20)	827	79.5	507	64.2	322	65.8
28. Total no. inaccurate, erroneous. (Items 5, 6, 12, 23, 24)	45	4.3	85	10.8	37	7.6
30. Total number of all statements	1041	100.0	789	100.0	489	100.0
31. Average no. of statements/pupil	34.7		26.3		16.3	
32. Miscellaneous topics mentioned only	152		113		251	

The thirty-five minute final essay test was more general in nature and required a different type of treatment. For this test, pupils were simply told to "write a summary of the outstanding principles, facts, and ideas of the semester's work." That sounds like a large requirement but the results were highly satisfactory and revealed more noticeable differences between the groups than did any of the other measures.

In analyzing these tests, each statement was underlined with a colored crayon, a different color being used for each type of statement such as: general principle or law, application or illustration, descriptive explanation, causal explanation, mere statement of fact, and mere reference to a topic. In addition, erroneous, inaccurate, incomplete, and vague statements of each type were so marked in the margin. The number of statements of each type was then tabulated for each paper and totaled for each group. Table II, giving the abbreviated results of these tabulations, shows much the same results as were noted for the topic-essay tests; that is, the "Outline" group showed certain consistent tendencies as follows:

1. Items 30 and 31 show a much greater total number of statements, i.e., greater association of ideas, for the "Outline" group.
2. Item 26 shows a larger percentage of clear, complete statements for the "Outline" group.
3. Item 32 shows a smaller proportion of isolated, unconnected topics merely mentioned.
4. Items 8 and 4 show a larger percentage of explanations, particularly of the cause and effect type.

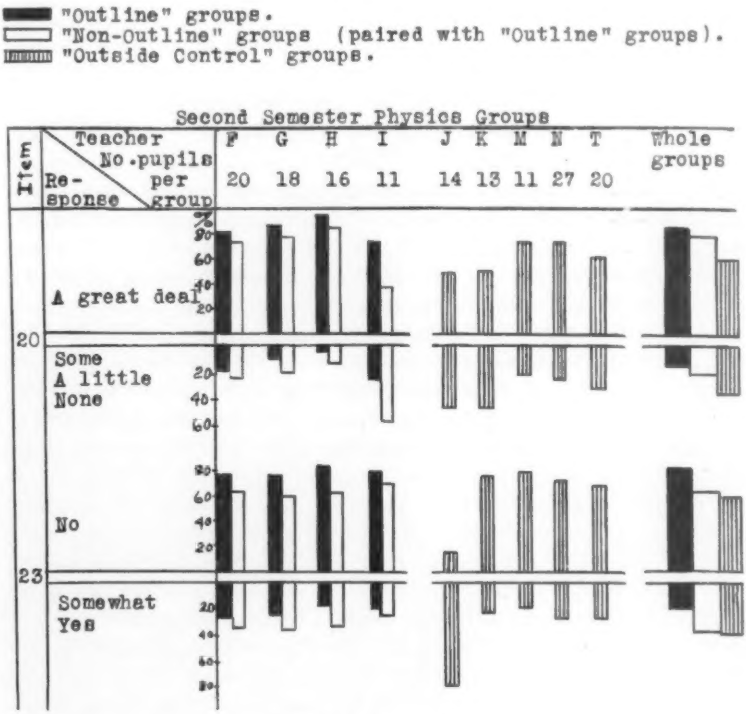
Besides this careful analysis, statement by statement, the papers were classified as to general type. The results of this classification could have been predicted from the data just given. That is, that in general, the papers of the "Outline" group tended to be much better organized, clear, and logical and to show a broader type of concepts and generalizations and a wider vision and grasp of the subject as a whole. In comparison, the papers of the other groups, and particularly of the "Outside Control" groups lacked organization, were sketchy, disconnected, vague, and even confused. Furthermore, the "Outline" groups showed, as before, the tendency to express causal relationships between facts rather than make bare, isolated, statements or vague references to some topic which had been studied.

All these facts are further verified and illuminated by the results of the questionnaire on study habits and attitudes. This was a check-questionnaire containing twenty-three very specific items concerning methods of study; for example, recalling the previous lesson, skimming the new lesson, and outlining for review.

Since the reliability of any questionnaire depends largely upon the way it is administered, a word must be said here on this point. The teachers

TABLE III

PER CENT OF PUPILS GIVING VARIOUS RESPONSES ON "HABITS AND ATTITUDES" QUESTIONNAIRE



ITEM 20. Do everyday things have more interest and meaning for you since studying physics?

A great deal................ Some................ A little................ None................

ITEM 23. Do you feel that physics deals with a wide variety of unrelated facts poorly organized?

Yes................ Somewhat................ No................

knew nothing of the questionnaire until they administered them, which they did according to typed directions as for a standard test. The pupils were given ample time to check the questionnaire under the same conditions of quiet as for a test. Questionnaires were not distributed until after the final grades were in, and even then, pupils were assured that the questionnaires would not be examined by their teachers but only by the experimenter, whom they did not know and who would hold their answers strictly con-

fidential. When the teachers were asked later concerning the pupils' attitude toward the questionnaires, they unanimously said the pupils had taken them seriously and had conscientiously tried to tell the truth.

The data for all of these items were treated in the manner shown in Table III. The complete data comprise forty-six charts similar to the two shown in this sample.

As in the other types of data, here again, the most striking feature is the consistency of the differences in favor of the "Outline" groups over their paired "Non-Outline" groups and "Outside Control" groups, with the exception of a few items where the differences are negligible. The better study-habits indicated by the complete questionnaire data are: to relate the lesson to previous ones, to skim the lesson first to formulate questions about it, to study diagrams carefully, to determine reasons for text statements, to supplement the text with original examples, to relate the lesson to things outside of class, to get a bird's-eye view of the lesson, and to outline the subject for review. These study-habits formed by "Outline" pupils doubtless account for their superiority in factual learning, their broader type of generalized concepts, their greater association of ideas, and their habitual feeling of need for cause and effect explanations, all of which were shown clearly by the objective data of both the new-type and essay tests.

The two items reproduced in Table III were chosen because of their particular significance, which is perhaps one of the most important outcomes of the study. Item No. 20 deals with the question, "Do everyday things have more interest and meaning for you since studying physics?" A glance at the table shows that the results themselves are meaningful, but they become more so when one knows the circumstances. Teachers J and K, of the "Outside Control" group are both interested primarily in the movement to "popularize science." Teacher J endeavors to do this by means of spectacular demonstrations, while teacher K employs a great many stereoptican slides, motion pictures, pupil-demonstrations, and field trips. Why this interest-response should be given by only 47 per cent and 50 per cent of their pupils, respectively, as compared to 85 per cent for the total "Outline" group and 76 per cent for the "Non-Outline" group is difficult to understand. But apparently the questions in the *Study Outlines* appealed more to the pupils, stimulated their curiosity more and suggested more "everyday" interests to them than did the other methods.

Item No. 23 shows responses to the question, "Do you feel that physics deals with a wide variety of unrelated facts poorly organized?" The fact that a greater percentage of "Outline" pupils than others answered "No" indicates that more of them felt satisfied with the course. This doubtless is due to the more definite learning on the part of these pupils on the broader

view of the course which they gained. Such mastery must always produce a feeling of satisfaction which a state of mental chaos cannot give. That the "Non-Outline" and more particularly the "Outside Control" groups possessed this chaotic state of mind was revealed by both objective and essay tests as well as questionnaires. Evidently what our pupils appreciate most after completing a course is that they have learned something of meaning in life, rather than that they have been entertained.

Summary

From this discussion it will be seen that the outcomes of this study are many and varied in nature. There was a definite attempt to define the aims and objectives of high school physics in respect not only to factual learning but to larger conceptual learning and valuable concomitants such as effective study-habits, problem-seeking and problem-solving attitudes, and attitudes of interest and satisfaction in the course.

The *Study Outlines* were constructed in an endeavor to apply the Laws of Learning to the attainment of these defined objectives. The three types of measures used to evaluate the *Outlines* gave consistently positive results in all respects and indicate that the use of challenging, direct questions arranged in outline form may be used to great advantage as a teaching device.

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[1] BLACK, OSWALD F. *Experimental Study of the Development of Certain Concepts of Physics.* "Die Weste" Potchefstroom, South Africa, 1931.

Launching and Maintaining an Elementary Science Program in a Large City System*

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Early in the fall of 1928 a program of curriculum construction in the field of science was launched in the Chicago public schools.

At that time there were no specific courses of study organized for any particular subjects. What was to be taught in chemistry in the twelfth grade, physics in the eleventh, botany and zoölogy in the tenth, and general science in the seventh, eight and ninth, was left to the various teachers in their respective schools and classes. The theory which attempted to justify this practice was based upon the assumption that each teacher, working independently, would develop initiative which would result in an improvement in his teaching that in turn would reflect in the quality of work done by his students. The facts were that the practice resulted in each class acquiring a set of textbooks, the contents of which they attempted to memorize as nearly as possible until such times as they were given periodic tests. It is likely that many students thereafter, having received credit in the course, proceeded to forget this information more rapidly than they had acquired it.

General science, so-called, was offered in the ninth grade in the senior-high school, five forty-five-minute periods per week for forty weeks, and in the junior-high schools two and one-half fifty-minute periods per week for forty weeks in each of the seventh, eighth and ninth grades. There was no other natural science of any kind offered in any grade below the ninth in any school excepting in a twenty-minute period allotted to that subject in the fourth grade.

For the past seven years Chicago has been gradually converting its school system from an eight-year elementary school, four-year senior-high school system, into the 6-3-3 plan of organization involving the use of the elementary school, junior-high school and senior-high school. Thus, part of its students enter the ninth grade of the senior-high school directly from the eighth grade of the elementary school; others leave the elementary school at the end of the sixth grade, attend the junior-high school for three years and enter senior high at the beginning of the tenth grade. Students who remained in the elementary school through eight grades received practically no work in general science until they entered senior-high school. Students

* Presented at the meeting of the National Council of Supervisors of Elementary Science, Washington, February, 1932.

who entered junior-high school received instruction in general science in grades seven, eight, and nine. It was intended that all students would have had some kind of a course in general science by the time their ninth grade work had been completed.

Before curriculum work could begin on a course in general science it seemed necessary to revise the time-allotment schedule for this subject in the seventh and eighth grades of the elementary schools, in order that students in these grades would have some opportunity to study science before they entered senior-high school.

Fortunately a revision of the time allotment for all grades of the elementary school was receiving consideration at this time by a committee appointed for that purpose by the Superintendent of Schools. This committee consisted of one assistant superintendent, two district superintendents, three elementary-school principals, and the director of curriculum. The supervisor of science, in charge of the science work of the curriculum, appeared before this committee and presented a case for a course of study in science to be built upon work which would involve experiences in that field, to begin in the primary grades and advance with the ability of the students in successive grades into the work of the senior-high school. In order that this committee might receive such suggestions favorably, it was necessary to define the objectives of such a course in a way that time devoted to this subject in these early years could be justified.

The position taken by the supervisor was that the objectives of the elementary schools were twofold: (1) To equip students with the tools of learning and to educate them to use these tools proficiently, and (2) To acquaint students with the raw materials of their environment, in order that they might visualize new relations between these raw materials which would enable them to develop understandings based upon these relations, and to think creatively in terms of such relations with the aid of the tools of learning. By the tools of learning were meant such subjects as reading, language (both oral and written), and arithmetic. In order that students attain proficiency in these subjects, it was customary to provide them with a working pattern. Pupils of a given grade were drilled in the manipulation of the subject matter contained in this working pattern until they had acquired sufficient skill, in the judgment of the teacher and principal, to enable them to attempt a more difficult pattern, to be presented in a succeeding grade. The major part of the thinking in any grade was done by the teacher. The thought was presented to the students in the form of a working pattern and they proceeded to use it in a manner much like the automatic machine. Thus they were deprived, in a large sense, of any opportunity to develop understandings through reflective or creative thought. Any

automatic machine can operate according to a thought set in a working pattern more accurately and efficiently than a human being. Therefore, we were developing a generation of boys and girls whose training would force them to compete in their activities of life with automatic machinery, a form of competition they could never hope to meet.

What they needed, in addition to this training, was a type of education which would furnish them with opportunities and activities that would bring them in contact with the raw materials and forces of nature in such a way that they would become familiar with these raw materials and forces, develop understandings concerning them, and learn to think creatively with them.

We conceived nature study to be the subject in which we learned to know nature as it was created and we conceived science to be the subject in which we not only learned to know nature as created, but in addition learned to change it, adapt it, and control it to the advantage of mankind. The objectives of science teaching then were summarized as follows:

(1) To develop understandings and appreciations of scientific problems, in order to learn how to control the environment;
(2) To learn to solve the problems of life by the scientific method and to establish this method of problem solving as a habit of procedure;
(3) To induce an emotional response in order to inspire a continued study in the field of science.

This argument induced the time-allotment committee to award eighty-five minutes per week to science and nature study in grades one and two, one hundred minutes per week in grades three and four, one hundred twenty-five minutes per week in grades five, six, seven, and eight of the elementary school. When this time-allotment schedule was accepted by the time allotment committee, recommended by the Superintendent of Schools and adopted by the Board of Education, and was published and distributed throughout the elementary school system of Chicago, the department of curriculum was besieged with requests for suggestions from principals and teachers regarding methods of teaching science and information concerning specific aims and activities for concrete lessons to be used in all of the grades affected. Hence, we were faced with three problems: (1) What immediate information could be placed in the hands of teachers in service which would be helpful during the current year? (2) How could teachers in service be educated to use this information properly and effectively? (3) What would be the nature of a more permanent course of study?

The first question was answered by organizing what was called an elementary-science weekly. Twice each week in Chicago, a bulletin is issued from the office of the superintendent, mimeographed, and mailed to

each of the five hundred schools in the system. The weekly occupied one page of this bulletin. It consisted of four problems in the field of nature study and elementary science in each issue, the four odd-numbered grades receiving their lessons the first half of the week and the four even-numbered grades receiving theirs the last half. After each problem, which was usually stated in the form of a question, activities were suggested through which a solution to the problem might be reached. At no time was the answer to the problem published, a fact which often produced some confusion and embarrassment to the untrained teacher but which forced her to carry out the activity if the problem was to be solved.

By this arrangement we succeeded in making the study of science a dynamic, active procedure, rather than a subject in which students were encouraged to memorize meaningless information. Supplementary reading for information about the problems under consideration was discouraged until some of the activity work with actual material had been accomplished. In fact, there were no elementary-science textbooks on our approved list until six months after this program had been started, and there are only three such texts on our list today, all of which are built around an activity program. Students were encouraged to feel that it was more important to learn to recognize a science or nature study problem, and to collect and evaluate evidence directed at its solution, than it was to learn the answer to the problem and believe that it was true because someone else said it was. In this manner we have hoped to give pupils opportunity to think creatively and independently, and they have often gone so far by themselves as to propose problems and activities which would lead to their solution, which indicates to us that we are beginning to achieve that which we set out to do.

The second question regarding the training of teachers in service was answered by holding demonstration lessons in the evening schools in the north, west, and south sections of the city. Such lessons were conducted under the supervision of the department of curriculum by teachers trained through that department especially for that work. Teachers attending these classes worked as nearly as possible under the conditions of the students in their respective grades. The teacher conducting the demonstration lesson used the actual material which he expected the teacher to use in the lesson of the classroom. The attendance at these classes was entirely voluntary and numbered approximately twelve hundred teachers per week.

Many of the teachers who attended these voluntary evening classes became demonstration teachers in their own schools or carried the message of the demonstration class to teachers' meetings. The work was conducted in a very informal, coöperative way. Each teacher attending the class

was furnished with a mimeographed summary of the work undertaken. The work was seasonal and the materials used were those which could be found most commonly throughout the city.

About a year after the elementary weekly and training classes were started a committee consisting of representatives of the Chicago Normal College, district superintendents, elementary principals and teachers, began work on the more permanent course of study. Due to the varying nature of the environment in a large city, it soon became apparent that no uniform set of raw materials would be available to all schools. Therefore, no minimum requirement was set, and it was further decided that the course should contain much more material than any one school could possibly use in a year. Through experimental lessons conducted in all kinds of schools working under all sorts of conditions, a group of suggested aims was developed for each grade. These aims were amplified with concrete lessons which might be carried out in different neighborhoods by students working with such material as they might gather themselves and bring into the classroom. The choice of what material should be emphasized in any particular school was left to the judgment of the district superintendent and principal under whose supervision the school functioned. If their choice was a study of insect life, a series of lessons in that field might be chosen. If their choice was in the field of physical science, then likewise suggestions in that field would be found. It was thought that attitudes and habits were of greater importance than subject matter, and that if proper interest in developing these habits and attitudes were aroused and maintained, the subject matter would go a long way to settle itself.

Chicago has a number of natural characteristics which make it necessary to handle elementary and nature study in a different manner in various parts of the city. The center of the city, about four miles square, contains practically no plant life, and its only animal life consists of human beings working in otherwise uninhabited shops and offices. Surrounding this area is one of the finest boulevard and park systems in the world. Along the lake front is a twenty-five mile strip of park from one to two miles in width which abounds in wild animal life, contains botanical and zoölogical gardens, the Academy of Sciences, the Field Museum, the Shedd Aquarium, and the Adler Planetarium. The conservatory, located in Garfield Park, is one of the largest and finest of its kind in the world. Almost surrounding the city are thousands of acres of natural forest preserves, in which plant and animal life flourish in their natural state. Within a few miles of the southeast corner of the city is the Indiana Dunes State Park. Further, outside the central business district, the city is studded with tiny neighborhood parks. All of the government agencies connected with these

parks and institutions have coöperated generously with the public school system to foster work in elementary science and nature study, even going so far as to have their employees broadcast information concerning their organizations on radio programs designed especially for the schools.

The writer of this paper does not pretend to hold any brief for the procedure that has been followed in Chicago. There are still schools in the system which have not succeeded in establishing a satisfactory program of elementary science and nature study. There has been no attempt to make any scientific evaluation of the value of the course from the standpoint of organization or effectiveness. However, we do know that there has been a tremendous increase in the amount of interest and activity in this field in the Chicago schools, and we feel that this justifies our efforts and that our experience is a step toward the solution of the problem which still confronts us, namely, What can elementary science and nature study offer the school children of Chicago?

Methods Versus the Mechanics of Instruction*

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It is, at first thought, quite amazing and yet, on further reflection, very significant that the various experimental studies that have been made on the comparison of the relative value of pairs of contrasting methods of teaching science have shown such small differences. The lecture-demonstration method has been found to be about as good as the individual-laboratory method, under present conditions, for many of the measurable outcomes. The unit-supervised-study method gives only slightly, if any, better results than the usual text-assignment-recitation method. The problem method in the laboratory yields trifle better results, in some studies, than the customary laboratory-guide method while, in others, the reverse is true. The project method seems to give significantly higher scores on the tests administered than the usual text-recitation method, in a few cases, while, in others, the differences are almost negligible. The use of work sheets produces no better grades than the customary procedure. Fill-in notebooks yield only slightly inferior results than those demanding a complete write-up of the activity.

These and similar studies are dealing, it seems to me, with the mechanics of instruction rather than the real techniques of teaching, for there is only one thing of prime importance that the teacher can do, namely, help pupils to acquire skill in learning. He cannot "learn 'em," to use an old inelegant phrase. He cannot teach them in the sense that by any sort of legerdemain he can transfer the knowledge which he possessses to the heads of his pupils. What they acquire they must gain for themselves. The teacher may help some by the maintenance of the conditions conducive to study, but his great opportunity lies in the development in his pupils of skill in learning.

It is highly significant that, in those experimental studies in which an effort has been made to give the experimental group of pupils facility in some learning skill, the test scores for this group have been consistently higher than for the control group and the longer such instruction is continued the greater are the differences in the scores of the two groups in favor of the experimental one.

Clem[1] made a study of the errors of pupils in high-school physics and

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* Address of the retiring president at the Washington meeting of the N.A.R.S.T., February, 1932.

then adopted modified teaching techniques designed to overcome some of the difficulties the pupils were encountering. He found that they often failed on certain questions of the tests because, in their answers, they did not use the technical terms understandingly, nor did they comprehend them in assigned readings. He tried to remedy this by providing pupils with a list of such terms in each lesson when assigned and holding the pupils responsible for mastering their meaning. In due time pupils became adept in spotting such terms for themselves and took the responsibility of clarifying them in their own minds.

He found that formulæ are stumbling blocks, for they are very abstract statements of the laws of physics and pupils of high school age deal in abstractions with difficulty. If forced to use formulæ at the outset they do so in a mechanical sort of way, not in an intelligent fashion. He, therefore, habituated pupils to state in words each principle involved in the solution of the problems that they were attempting to solve. When they began to use the formulæ of their own accord, recognizing them as brief statements of the laws, they were permitted so to do. Thus pupils gained skill in intelligently applying the laws to problems.

Pupils were given exercise in picking out the pertinent elements in a problem for they found problem solving a difficult task. By thus developing skill in detecting the essential things in a problematic situation they acquired greater facility in their solution.

Again, he found that pupils attacked their laboratory work piecemeal, following each step of the directions without having any clear idea of its part in the whole, without realizing what the experiment was for or seeing the relation between the laboratory exercise and the discussion in the text. He, therefore, devised questionnaires which forced pupils, as they filled them out, to become aware of these and similar items before they were permitted to proceed with the laboratory work. Such work became increasingly significant and was done more intelligently and more skillfully.

As a result of these four modifications of his teaching techniques the average grade of the experimental group on the final standardized tests was about 16 per cent better than that of the control groups, that is, the classes of the two preceding years, which had not had the benefit of the revised techniques.

Powers[2] shows how disappointingly incomplete is pupil mastery of the things the instructor is trying to teach. Given the names of chemical compounds and required to write their formulæ, pupils make scores on this item of the standardized test ranging from 88.1% to 3.8%. Their trouble is mainly in recalling valences. Asked such questions as "What will happen if a solution of sodium chloride is added to one of silver nitrate?", they fail to answer

correctly in a large percentage of cases, apparently because they can not remember the metallic displacement series. Given a simple problem like "How much iron can be obtained from a ton of magnetite, Fe_3O_4?", again many fail because they can not remember the needed atomic weights.

The diagnosis appears quite evident. The failure of the pupils is due to their inability to recall a lot of disconnected facts. And the remedy is equally apparent—teach them how to memorize the needed materials. Now one of the most important elements in facile recall is organization. The chemist does not try to hold all these details in mind as a mass of isolated and independent items. For him, these and many others are organized into a related whole by the periodic law.

Hunt[3] made a study in which the experimental group was introduced to the periodic law about six weeks after the course began while the control group took up this subject where it occurred in the text book, well toward the end. In each case the importance of this law, as a means of organizing factual material so it can be held in mind, was discussed. Pupils were told that if they would read over *attentively* the tabular statement of this law, as it appeared in the text, once a day, that it would be fixed in mind within a month or so. Then they were advised not to stop at that point but to continue the process for another two weeks so they would get well beyond the threshold of memory and it would be learned "for keeps." They were further instructed that it would help in the memoriter process if each would, for himself, try to organize this list of symbols, that has no readily apparent sequence, into a coherent whole, even if it had to be done in a wholly artificial way.

Here, for instance, is one suggestive device.

He Li Be B C N O Fl.
  HeLi, BeB(o), C(a)N(i), O(we), Fluorine
Ne Na Mg Al Si P S Cl.
  Nena, My gal, sips, chlorine
A K Ca Sc Sb V Cr Mn—Fe Co Ni
  AKCa, Scanti, 5 Cro Man, Feconi,
Cu Zn Ga Ge As Se BR
  Cousin Gagé (h)as se(en) Bromine.

This is merely a suggestion to make clear what the instructions mean. Pupils may adopt it if they wish and continue it or they may work out some device of their own.

As a result of introducing this periodic law early as a means of organizing chemical facts to facilitate memorizing and of giving instruction on ways and means of fixing it in mind, the final median grades of the experimental group using standardized tests was some fourteen per cent higher than that of the control group.

Beauchamp[4] found that if pupils are given two objects to compare, that the written statements they prepare give very few similarities and differences and these few are listed in no orderly fashion. The experimental group of pupils was then instructed to make a list of the possible categories of similarities and differences. Thus if a hard maple leaf and a white oak leaf are to be compared it would be on (1) form, (2) size, (3) character of the margin, (4) venation, etc. Then under each of these they were instructed to note all the differences they could see, then all the similarities. After several exercises in this procedure with pairs of objects or phenomena, they developed such skill that their later statements, on tests devised for the purpose, listed many more similarities and differences than did the statements of the uninstructed group and these were arranged in a more systematic manner. When it is remembered that the most used method of reasoning is the method of similarities and differences, such instruction seems very worth while.

There is nothing startling about these results, they are what common sense would lead us to expect. Teach a pupil how to do a thing and he will do it better than one who has not been so taught. The startling thing is that so few teachers act in accord with common sense. We assign the pupils a learning task and then let them flounder as best they can. Those that splash around in desperation and finally win through to safety we reward with a 90% or a 95%, or a 98%, depending on the form they manifest at the finish. To those who in the excitement of the occasion give up and sink, we give an "F" (a flunk), and never think of extending a helping hand, much less of teaching them the strokes before we take them into the water.

There have been cited above but a few of the rapidly accumulating studies that show the value of instructing pupils in the techniques of learning. The studies of methods that deal really with the mere mechanics of instruction are rather barren but those which have to do with the development of skills in learning are in a fruitful field. It behooves the science teacher to be concerned less with imparting what he knows and more with the ability of the pupil to acquire the desirable outcomes. Focus attention not on youı teaching but on the pupil's learning.

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Teaching Biology*

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Many who should know the situation state that biology is one of the most poorly, if not the most poorly, taught subject of the high-school curriculum. A study should be made of this situation and, if this seems to be generally true, action should be taken accordingly. It does seem true that there is not a good standard course or text in general use. This may reflect on the training of the teachers or it may reflect on the way they try to present the course—for example a year in the subject called biology versus a year in which botany is taught one semester and zoölogy the other. It seems logical to believe that in a course in biology the high-school mind is not ready—does not have the background—to go from a tulip to a grasshopper or frog with a clear conception of any principles that may be common to both. It is too big a jump. It would seem better to give botany followed by zoölogy and then tie them together at the end of the year. The youth in high school needs a background of facts before comparative anatomy or physiology can be grasped intelligently. It is possible that mature, trained minds have developed the present so-called biology course in an attempt to save time or short cut in the subject. In doing this they have lost sight of the problems of the high-school mind. Botany and zoölogy can be so well arranged as separate fields that if time is a factor why not reduce the time devoted to each? Pittsburgh offers the two fields in place of the one and this is undoubtedly one factor contributing to statements by college men that the Pittsburgh students are better trained and prepared for college work in biology than the average of the other schools of western Pennsylvania.

Many students entering a college course in biology say, "We had all this in high school." Cannot we have a high-school course that is distinctive? Why not a course that approaches the subject more from an ecological (nature study) viewpoint? Such a course would mean much more to them than the logical college course brought down to a high-school level. It would mean more field and museum work. This is the way the first scientists learned. First hand information sticks. Base the units around a school yard, a stream, pond, woods or swamp—whatever is available. Study the light, heat, water, soil, and other factors of the environment. Then

* Delivered at a meeting of the Biology Section of the Western Zone of the Pennsylvania State Education Association.

the presence of organisms and their habits will be better understood. The organism cannot be separated from the environment. Show the adaptations that make it possible for organisms to survive in hostile conditions.

In this industrial city show how the origin of this thing we call a scientific civilization is based on life of the past. Practically everything today, be it automobiles, ships, pictures or food, comes from life of the past or present. Trace steel from the coal, limestone, and iron ore which are largely products of life of the past.

Make your courses economic. Tie them up with local industries and social needs. Develop the biological basis of human activities. Make sure that the scientific method holds a bigger place in classroom technique than mere fact gathering. Both are important, but if training in logical thinking can be successfully accomplished a most important end has been attained. Facts will be forgotten but a habit of thinking will remain. How subject-matter is taught counts more than what is taught. Better to have a few facts scientifically developed than many passed out as mere information.

The lack of mastery of subject matter by the instructor is certainly another factor that contributes to poor teaching in any field, and in biology the condition is perhaps more universally prevalent. Too many fail in showing or demonstrating facts successfully. No experiment should ever fail before a class. Visiting successful teachers by the inexperienced would be one of the best steps that could be taken to improve biology teaching.

Teachers, especially biology instructors, should be enthusiastic. No one is a really successful teacher unless "sold" on the value of his subject, although the value of other fields of knowledge should be recognized. Personality, that extremely valuable asset of a teacher, is developed by enthusiasm plus mastery of subject matter plus a sympathetic understanding of the pupil. Teachers of biological science have a big task—a task that demands much in directing the thought of young folks into accurate observation and thinking. From such experience will come at least a few adults with the simplicity to wonder, ability to question, and power to generalize and to apply. Such people are truth seekers and there are too few in society. It is they that become the workers, thinkers, and doers upon which the world is absolutely dependent for the preservation, diffusion, and advancement of science, in this scientific civilization. It is they who "bring the power and the fruits of knowledge to the multitude who are content to go through life without thinking and without questioning, who accept fire and the hatching of the egg, the attraction of a feather by a bit of amber, and stars in their courses as a fish accepts the ocean."

To be good instructors we should be outstanding examples of the profession. We should live our ideas. Young folks will recognize how happy

and enjoyable is life when it is lived scientifically. What a joy it is to be a disseminator or diffuser of knowledge, believing that this knowledge brings home to everyone the wonders and harmonies of life, that existence may be better ordered, life bettered, and minds lifted to higher levels.

We are builders of minds. Shall we realize that an understanding of our subject is vital to a successful sojourn on this earth? We who do not realize our duty to society may be forgiven perhaps, but he who knows and doesn't disseminate is almost a criminal. At least we fall far short of our duty. The space we occupy should be worth the effort.

Do Teachers of Chemistry Know Their Physics?

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We pride ourselves upon keeping up-to-date in chemistry, although it involves no little labor on our part. We read the reviews of new texts and even the books themselves with a view to finding better teaching tools. We attend meetings whenever and wherever possible in order to listen to papers presented by wiser and more experienced educators. We subscribe for the magazines in our field and read the articles faithfully. We go to summer school and even take a year off to attend graduate school where we have close and stimulating contact with great teachers and interesting co-workers. But do we teachers of chemistry try to keep up with the wonderful developments in the field of physics?

"Why physics?" you may ask, since we can not possibly learn all that is being done in chemistry. "Why not physics?" comes the reply, since you can not understand the principles of your own science without a foundation of physics. Again we ask, can you appreciate the "very complete change in man's whole intellectual and spiritual outlook"[1] which followed the "development of Galilean and Newtonian mechanics"[2] unless you have a background in physics? The answer is, you can not. Then how can you hope to appreciate the boundless significance of the "six basic principles" which Millikan[3] lists, or the changes which have now entered into our interpretations of these principles?

These "six basic principles which, at the end of the nineteenth century, acted as the police officers to keep the physical world running in orderly fashion"[4] are listed below, with certain discoveries which have affected them greatly, namely:

1. The principle of the conservation of the chemical elements;
2. The principle of the conservation of mass;
3. The principle of the conservation of energy;
4. The principle of the conservation of momentum;
5. The principle underlying Maxwell's electrodynamics;
6. The principle of entropy or the second law of thermodynamics.

The first was nullified by the discovery of radioactivity, the second by the discovery of the increase in the mass of the electron at high velocity, the third is greatly affected by the Einstein equation $MC^2 = E$, the fourth quails before the quantum theory, the fifth is invoked in vain when we try to explain atomic mechanics, the sixth now admits "exceptions"[5] when "interpreted in terms of probability."[6] Does the average teacher of chemistry

know about these principles and these discoveries which have so affected them? We ask to know.

Millikan goes on to list the important discoveries in the field of physics, within this century, and it would be both interesting and illuminating to find out how much or how little the teacher who confines himself or herself to the field of chemistry knows about them. Here is the list:

1. The discovery of the electron;
2. The discovery of X-rays;
3. The discovery of quantum mechanics;
4. The discovery of the principle of relativity;
5. The discovery of radioactivity;
6. The discovery of the nuclear atom;
7. The discovery of crystal structures;
8. The discovery of atomic numbers;
9. The discovery that the energy communicated to electrons by ether waves is proportional to the frequency of the absorbed waves;
10. The discovery of the meaning of spectral lines;
11. The discovery of isotopes (and isobars).
12. The discovery of "the excited atom";
13. The discovery of the artificial disintegrability of atoms;
14. The discovery of the meaning of spectroscopic fine structure;
15. The discovery of new experimental technics for seeing invisible ether waves;
16. The discovery of new properties in conduction electrons;
17. The discovery of quantum jumps inside the nucleus;
18. The discovery that the law of the conservation of momentum is applicable to the encounter between a light quant and a free electron;
19. The discovery of the summation of two or more quantum jumps into a single monochromatic ether wave;
20. The discovery of the failure of the Relativity Explanation of all relativity-doublets;
21. The discovery of cosmic rays.[7]

What, you chemistry teachers, do you know about these?

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[1] Millikan, Robert A. *Science and the New Civilization.* New York: Charles Scribner's Sons. 1930. p. 114-115.

[2] Millikan, Robert A., *op. cit.* p. 114.

[3] *Ibid.* p. 115.

[4] *Ibid.* p. 115.

[5] *Ibid.* p. 116.

[6] *Ibid.* p. 116.

[7] *Ibid.* p. 117-133.

Some Refinements of the Familiar Photosynthesis Experiment

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Discussion with many science teachers has convinced the writer that he is not alone in his troubles with the conventional experiment which attempts to show that sunlight is necessary for photosynthesis. As most texts and manuals give rather scanty directions and seem to err by giving too short a time for most of the steps, the following technique is suggested as a means of diminishing the number of embarrassments so common with this experiment.

Method One. *Pin thin strips of cork underlaid with black paper on each side of a healthy growing green leaf. Time 4-8 days.*

Thin strips of cork can be cut from a large size cork stopper with a straight razor, and black paper can usually be obtained from the art department. The light-weight flexible paper conforms more closely to the contour of the leaf's surface, thereby shutting out more light, and as the paper is black, any stray beams entering will be absorbed. The cork sheets will be held together more firmly if three pins are thrust through the entire combination at a different angle to each other.

It is best to avoid plants having waxy leaves such as the begonia. The common geranium is better and usually at hand. An interesting variation is the use of certain foliage leaves containing red or white as well as green. It is not necessary to place the plant in direct sunlight as long as the other parts of the leaf remain green. A still further ramification is the placement of one plant in the dark room with strong artificial light. It is better to cover the outer edge of the leaf rather than the base, otherwise the starch produced at the outer edge will be withdrawn through the covered section.

When the paper and the cork are removed, the leaf should be pale yellow where it was covered. Many of the pupils have noticed this effect on grass that has been covered with a board or stone and this item of scientific background can be tied in at this time. Occasionally when a leaf has been covered for more than four days the section covered becomes withered and dry. If so, the leaf must be discarded, but in this case one knows his failure before beginning the chemical aspect of the experiment. To surmount this difficulty it is best to cover parts of several leaves. Any extra covered leaves in good condition can be carried through only a part of the succeeding steps so that at the end of the experiment there is a leaf to represent each phase.

METHOD TWO. *Boil the previously covered leaf or leaves in two separate applications of alcohol. Time 8-12 minutes.*

It is advisable, to better exemplify the scientific method, to include in this and succeeding steps an uncovered green leaf as a check or control for contrast.

To completely remove all chlorophyll the leaves must be boiled in a second application of alcohol. The first application becomes so green that we occasionally dye a handkerchief in it.

Before the alcohol begins to boil the writer usually places an asbestos mat or cardboard on the demonstration table and in a conspicuous manner takes down the Pryene fire extinguisher or a bottle of carbon tetrachloride. The inquiry which this never fails to provoke is turned back to the pupils and develops into a brief review of kindling temperatures, vaporization, the extinguishing of fires, and it sometimes leads to a consideration of the danger of using gasoline indoors. If necessary, we purposely set fire to the boiling alcohol as a culmination to our discussion in order to have practice in extinguishing the fire.

METHOD THREE. *Boil the leaves in water. Time 5-10 minutes.*

Starch grains give a better reaction with iodine if their cell walls have been disrupted by boiling. As alcohol boils at a temperature considerably lower than water it does not appreciably cook the starch. Here again some of the pupils will have a scientific apperceptive background which can be used. Most of them are aware of the fact that anti-freeze alcohol boils away before water does in automobile radiators and that it boils at a lower temperature. A few may have tried to boil potatoes at a high altitude and are aware that they do not cook as rapidly with a lower temperature.

METHOD FOUR. *Saturate the leaves with alcohol. Time 3-5 minutes.*

Iodine is nearly insoluble in water and the presence of a large proportion of water in the leaf interferes with the penetration of the iodine solution.

METHOD FIVE. *Soak the leaves in a strong solution of iodine in alcohol. Time 8-10 minutes.*

The external cells of the leaf prevent the rapid infiltration of the iodine solution so that it slowly changes its color. Extending the time of this step and the succeeding one to thirty minutes will give even better results, but it does not permit the completion of the experiment in a single class period.

METHOD SIX. *Wash twice in alcohol. Time 6-8 minutes.*

This process removes the iodine that has not combined with starch, makes the covered section of the leaf, a lighter color, thus materially assisting in giving a greater contrast between the covered and uncovered sections of the leaf.

Ability Standards for General Science

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Pupil achievement in a school subject is conditioned by a considerable number of variable factors. The mark a pupil makes on an achievement test is one measure of the result of the interaction of these causal factors. The fact that these conditioning factors are not present or do not exercise their effect in the same degree upon each pupil explains the individual differences and variability in achievement that teachers commonly find in their classes.

Intelligence is one of the most important of these factors that affect achievement. While the coefficient of correlation between intelligence test scores and achievement test scores is never +1, it has been demonstrated by experiment that the correlation approaches unity as pupils are "maximally or equally motivated." "Indeed," says Symonds, "no other single factor has been found that conditions achievement in this inclusive way."

This investigation deals with a study of the relation of mental ability to achievement in general science. Two things are attempted: (1) to show the relation of intelligence to achievement in high-school general science, and (2) to set standards for achievement in general science in terms of the scores on an intelligence test.

Collection of Data

In the fall of 1928, letters were sent to a number of general-science teachers in the United States explaining the purpose of this investigation and asking them to coöperate in the study. Of the schools replying favorably, ten,* fairly well distributed geographically, were chosen to carry on a testing

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* The author is indebted to the following teachers and schools who assisted in the testing program:

Baer, Ruth E., High School, Emmittsburg, Md.
Carrol, B. S., High School, Trappe, Md.
Cochran, Samuel G., Commerce H. S., Yonkers, N.Y.
Cuzner, Hazel, Albert Lea H. S., Albert Lea, Minn.
Davee, H. A., High School, Geraldine, Mont.
Flatt, John B., High School, Twin Falls, Idaho.
Hosfeld-Hamparian, Francis, High School, Fort Lee, N.J.
Kennedy, R., Junior High School, Maplewood, N.J.
Le Mahieu, James, High School, Grafton, Wis.
Smith, Charles, Radnor H. S., Wayne, Pa.

The following teachers coöperated in the 1929-30 program:

Fletcher, Cora T., High School, Concord, N.H.
Schultz, W. R., High School, Faribault, Minn.
Carroll, Benjamin S., High School, Trappe, Md.
Albertson, Mary S., High School, West Palm Beach, Fla.

program during the year. Due to the failure of several teachers to report data for December 1 and March 1, it was necessary to continue the testing during the school year of 1929-1930.

In each of these schools the Terman Group Test of Mental Ability was administered to the pupils early in the fall, most frequently during the month of October. Either Form A or Form B was used. In one of the coöperating schools, the Terman Test had been given in the fall of 1927 but not 1928. The Terman Test scores of the pupils studying general science in this school were corrected to 1928 by means of the regression equation,

$$Y_{\text{gain}} = -169\ X_{\text{score}} - 40.62$$

and a table for estimating yearly gain on the Terman Test for high school pupils, both of which have been derived by Symonds.

Pupil achievement in general science in these schools was determined three times during the year (December 1, March 1, and June 1) by means of the Powers General Science Test. In November, the following set of directions was sent to the coöperating schools.

Directions to Coöperating Schools

Under separate cover, I am sending copies of the Powers General Science Test, Form A. The dates set for the testing during the year, you will recall, are December 1, March 1, and June 1. This group of tests need not be given exactly on December 1, within a week before or a week after will be satisfactory.

To insure uniformity in the testing program, the following set of directions has been prepared. Please read them very carefully.

1. The Powers General Science test normally requires a full period to be administered. Since much of the material in the test will not have been covered by December 1, a full period will not be required at this time. Collect the tests as soon as the pupils complete them.
2. The teachers should not discuss the tests with the pupils after they are taken. This test Form A will probably be given again during the year and to discuss the test or answer pupils' questions may invalidate future testing.
3. Teachers should not modify their teaching procedures because of the testing program. Continue your work as you normally do it. A number of schools throughout the United States are coöperating in this investigation which should furnish a measure of achievement in General Science under normal teaching conditions.
4. Do not make any attempt to prepare classes directly for this test. To do so would defeat the purpose of the investigation.
5. Do not give the test to pupils repeating the course in General Science.
6. On the front page of each test, in the upper right hand corner write the pupil's Terman Test score (please note score not I. Q.).
7. Please send me the December 1, tests as soon as possible after they have been given. I hope I may have all of them by December 15.

Similar procedures were followed for the tests on March 1 and June 1 with the exception that the Powers General Science Test, Form B, was used for the test on March 1. Form A was again used for the test on June 1.

Treatment of the Data

The scores made on each test at each period of testing were distributed in a scatter-diagram by plotting the Terman Test scores along one axis and the Powers Test scores along the other. Table I gives the distribution of these scores for each period of testing.

TABLE I

DISTRIBUTION OF SCORES ON BOTH TESTS FOR EACH PERIOD OF TESTING

December 1				March 1				June 1			
Terman		Powers (A)		Terman		Powers (B)		Terman		Powers (A)	
Score	f	Score	f	Score	f	Score	f	Score	f	Score	f
170	4	54	5	179	2	62	2	184	1	83	1
163	1	52	1	172	3	60	3	177	6	80	0
156	1	50	5	165	1	58	8	170	3	77	2
149	8	48	11	158	2	56	4	163	6	74	2
142	19	46	12	151	7	54	4	156	6	71	10
135	13	44	10	144	9	52	8	149	21	68	10
128	23	42	9	137	11	50	16	142	21	65	10
121	29	40	32	130	30	48	15	135	16	62	20
114	48	38	17	123	18	46	24	128	29	59	26
107	33	36	39	116	39	44	13	121	42	56	25
100	49	34	25	109	39	42	26	114	23	53	42
93	39	32	43	102	48	40	38	107	41	50	32
86	41	30	38	95	29	38	28	100	39	47	37
79	27	28	36	88	51	36	34	93	43	44	48
72	34	26	22	81	32	34	45	86	42	41	47
65	17	24	32	74	35	32	30	79	21	38	28
58	15	22	28	67	26	30	45	72	22	35	17
51	4	20	19	60	9	28	15	65	15	33	31
44	3	18	3	53	8	26	22	58	9	29	13
37	1	16	16	46	2	24	10	51	11	26	14
30	1	14	0	39	4	22	7	44	6	23	2
		12	0	32	3	20	7	37	3	20	2
		10	7			18	4	30	1	17	2

TABLE II

SUMMARY OF TEST RESULTS FOR DECEMBER 1, MARCH 1, AND JUNE 1

Date	N	Terman Test				Powers Test			
		Med.	Q_1	Q_3	Q	Med.	Q_1	Q_3	Q
December 1	410	104.0	86.1	120.3	32.4	32.2	25.8	38.0	12.2
March 1	408	102.7	84.3	119.5	35.2	37.1	31.6	43.6	12.6
June 1	421	106.7	88.9	127.6	38.7	47.5	40.6	56.1	15.5

Medians, quartiles, and semi-interquartile ranges were calculated for both tests at each period of testing. All of these data are summarized in Table II.

The coefficients of correlation between the Terman Group Test of Mental Ability and the Powers General Science Test were calculated for each period of testing by the product-moment method. These coefficients are shown in Table III.

TABLE III
CORRELATION BETWEEN TERMAN GROUP TEST OF MENTAL ABILITY AND THE POWERS GENERAL SCIENCE TEST

December 1	.35
March 1	.42
June 1	.67
Average	.48

The statistical method of deriving the standards for June 1 will now be described in detail. The reader should refer to Table IV. In column one, the per cents by steps of 5 to 100 are given. The figures in column two were obtained by multiplying 421 (N) by the percentages in column one. The next section of the table shows the data and computation of every fifth percentile value for the distribution of scores for the Terman Test. The last section shows the data and computation of every fifth percentile for the distribution of scores on the Powers General Science Test.

TABLE IV
COMPUTATION OF ABILITY STANDARDS FOR JUNE 1

%	%×N	Terman			Powers		
		Score	f	Percentile Values	Score	f	Percentile Values
100	421.00	184–190	1	$156+\frac{.95}{6}\times 7=157.0$	83–85	1	$68+\frac{3.95}{10}\times 3=69.2$
95	399.95	177–183	6				
90	378.90	170–176	3	$149+\frac{.9}{21}\times 7=149.0$	80–82	0	$62+\frac{12.90}{20}\times 3=63.9$
85	357.85	163–169	6		77–79	2	
80	336.80	156–162	6	$135+\frac{10.85}{16}\times 7=139.7$	74–76	2	$59+\frac{17.85}{26}\times 3=61.1$
75	315.75	149–155	21				
70	294.70	142–148	15	$128+\frac{18.8}{29}\times 7=132.5$	71–73	10	$56+\frac{21.80}{25}\times 3=58.6$
65	273.65	135–141	16				
60	252.60	128–134	29	$121+\frac{39.75}{42}\times 7=127.6$	68–70	10	$56+\frac{.75}{25}\times 3=56.1$
55	231.55	121–127	42		65–67	10	

TABLE IV (*Cont.*)
COMPUTATION OF ABILITY STANDARDS FOR JUNE 1

%	%×N	Terman			Powers		
		Score	f	Percentile Values	Score	f	Percentile Values
50	210.50	114–120	23	$121+\frac{18.7}{42}\times 7=124.1$	62–64	20	$53+\frac{21.7}{42}\times 3=54.6$
45	189.45	107–113	41		59–61	26	
40	168.40	100–106	39	$114+\frac{20.65}{23}\times 7=120.3$	56–58	25	$53+\frac{.65}{42}\times 3=53.0$
35	147.35	93–99	43				
30	126.30	86–92	42	$107+\frac{40.6}{41}\times 7=114.0$	53–55	42	$50+\frac{11.60}{32}\times 3=51.1$
					50–52	32	
25	105.2	79–85	21	$107+\frac{19.55}{41}\times 7=110.4$	47–49	37	$47+\frac{27.55}{37}\times 3=49.2$
20	84.20	72–78	22				
15	63.15	65–71	15	$100+\frac{37.5}{39}\times 7=106.7$	44–46	48	$47+\frac{6.50}{37}\times 3=47.5$
10	42.10	58–64	9				
5	21.05	51–57	11	$100+\frac{16.45}{39}\times 7=103.0$	41–43	47	$44+\frac{33.45}{48}\times 3=46.1$
		44–50	6		38–40	28	
—	—	37–43	3	$93+\frac{38.4}{43}\times 7=99.3$	35–37	17	$44+\frac{12.40}{48}\times 3=44.8$
—	—	30–36	1	$93+\frac{17.35}{43}\times 7=95.8$	32–34	31	$41+\frac{38.35}{47}\times 3=43.4$
					29–31	13	
—	—	—		$86+\frac{38.30}{42}\times 7=92.4$	26–28	14	$41+\frac{17.30}{47}\times 3=42.1$
					23–25	2	
—	—	—		$86+\frac{17.25}{42}\times 7=88.9$	20–22	2	$38+\frac{24.25}{28}\times 3=40.6$
—	—	—		$79+\frac{17.20}{21}\times 7=84.7$	17–19	2	$38+\frac{3.20}{28}\times 3=38.3$
—	—	—		$72+\frac{18.15}{22}\times 7=77.8$	—		$32+\frac{30.15}{31}\times 3=34.9$
—	—	—		$65+\frac{12.10}{15}\times 7=70.6$	—		$32+\frac{9.10}{31}\times 3=32.9$
—	—	—		$58+\frac{.05}{9}\times 7=58.0$	—		$29+\frac{1.05}{13}\times 3=29.2$

The corresponding percentiles are next plotted on a sheet of cross-section paper. The points are joined so as to form a straight line. If the points are not already in a straight line a line of best fit is made by use of "judgment, eye, and pencil." From this line values are ready for the Powers General Science Test, for every five points of score on the Terman Test,

These values are the ability standards. Table V gives the standards for December 1, March 1, and June 1.

TABLE V
ABILITY STANDARDS FOR POWERS GENERAL SCIENCE TEST

Terman Score	December 1	March 1	June 1
165	55.5	59.5	68.7
160	53.5	57.5	66.7
155	51.7	55.5	64.7
150	49.8	53.8	62.7
145	48.0	52.0	60.7
140	46.0	50.5	58.7
135	44.5	49.0	56.7
130	42.5	47.0	54.7
125	40.5	45.5	52.6
120	39.0	44.0	50.7
115	37.5	42.0	48.6
110	35.0	40.6	46.7
105	33.0	39.0	44.6
100	31.7	37.5	42.7
95	30.0	35.8	40.7
90	28.4	34.0	38.7
85	26.5	32.5	36.7
80	24.5	30.8	34.7
75	22.7	29.0	32.6
70	20.7	27.0	30.6

The ability standards which are given in Table V may be used in at least two ways:

(1) *To estimate the efficiency of a pupil.* To do this the teacher must have, first of all, a score on the Terman Group Test of Mental Ability which was administered to the pupil near the beginning of the school year. Suppose a pupil's score on the Terman Test is 120.0. On or near December 1, he makes a score of 39.0 on the Powers General Science Test. By referring to Table V we see that the achievement of this pupil is the same as the average pupil having the same ability. In other words this student is progressing normally. In a similar manner the pupil's progress during the year can be checked by administering the Powers General Science Test on March 1, and again on June 1, and comparing his scores with the standards in Table V.

(2) *To estimate the efficiency of a class.* This can be done by computing the average Terman score for the class and the average score on the Powers General Science Test, and then following the same procedure used in estimating the efficiency of a pupil.

How We May Meet Individual Differences in High School Chemistry

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General Plan of the Course

In an effort to solve the problem of individual differences among students, the author has used the flexible assignment plan in his chemistry classes for the past two years.

Each student will have a set of worksheets to direct him in his study of a definite unit of subject matter. In order to allow for individual differences, the subject matter is divided into three divisions: *Minimum, Average* and *Maximum Assignments*. The *Minimum* designates the minimum work which the student must satisfactorily complete in order to obtain a passing grade and credit for the unit. The *Average* and *Maximum* assignments suggest additional, related work that the average and superior students may do and thereby receive additional credit in proportion to the portion of the additional work which they have satisfactorily completed. References are given for supplementary work and there is opportunity for each individual to work as fast and as far as he wishes along the lines of his own interest after he has mastered the fundamentals of the unit. Since much of the work will be done in the classroom or laboratory, there is more opportunity for the teacher, acting as a guide, to supervise the work and also the amount of home-study is reduced considerably.

Units of the Entire Course

1. Measurement and Chemical and Physical Changes.
2. Oxygen: Sources, Preparation, Properties, Uses.
3. Hydrogen: Sources, Preparation, Properties, Uses.
4. Water and Solution, including the Laws of Definite and Multiple Proportions illustrated by the Composition of Water and of Hydrogen Peroxide.
5. Atoms and Molecules: Electron Theory (by aid of models). Atomic Hypothesis, Valence, Symbols, Formulas and a brief Introduction to Chemical Equations.
6. Chlorine: Preparation, Properties, Uses; and its Compounds, emphasizing Hydrochloric Acid and its Preparation, Properties and Uses.
7. Equations and Types of Chemical Reaction; Why Reactions Go to Completion; Reversible Reactions.
8. Chemical Arithmetic: Common Types of Problems and Their Application to Chemical Equations.
9. Sodium, Potassium and Their Compounds.
10. Ionization, Neutralization, Equilibrium, Mass Action.
11. Sulphur and Sulphides.
12. Oxides and Acids of Sulphur.

13. Nitrogen and the Atmosphere, and Nitrogen Compounds.
14. Halogens and Their Compounds.
15. Carbon, Carbides and Oxides of Carbon.
16. Calcium and its Compounds.
17. Metals and Metallurgy.
18. Organic Compounds.
19. Radioactivity and any other topics that are optional.

Plans Used Within Each Unit

The plan which is used within each unit very closely resembles the general plan already described in respect to the three-level organization. However, each unit may be divided into several problems which are related to each other quite closely. Also, class or group conferences are held at frequent intervals for explanation of the aims of the unit and its purpose in the entire course, for general discussion of the unit, or for the teacher to explain any topic that seems to be particularly difficult or of especial importance in the course. Moreover, there is a written examination prepared to test the achievement of the students in each of the three levels of work assigned. This, together with notebooks, conferences, individual supervision, *et cetera,* assists the teacher in evaluating the work of any student for any one or for all three levels of the work in the unit being studied. This examination (such as one appearing later in this article) may be taken by each student as soon as he has completed the corresponding portion of the unit, that is, a *Minimum, Average* or *Maximum* assignment.

Introductory Talk to a Chemistry Class

"SO YOU ARE GOING TO STUDY CHEMISTRY?" Undoubtedly you think this is a very peculiar question for me to propose to you today. Some time ago I was in a book store where I noted many books entitled as follows: SO YOU ARE GOING TO PARIS?, SO YOU ARE GOING TO SWITZERLAND? Of course, it seems very natural that anyone who thinks of touring more or less strange lands, either for business or pleasure, will wish to know something of what he may expect to see, learn, and enjoy during his trip. Consequently, some men and women who have visited various countries have written a series of books for the benefit of tourists such as I referred to a moment ago.

Although you do not want so much advance information that the novelty of the trip will be ruined, you do wish to know how you are going and what things are most worthwhile to see and enjoy in the limited time you have to spend. Also, a good guide and some guide books are very valuable to you on your tour. Furthermore, you do not want a guide to see, learn, and enjoy all the things for you because you desire to do most of that for yourselves.

Hence, you want a guide who is interested in his work, one who is always ready to help each member of the party, one who has the interests and welfare of his party at heart, and one who will vary his explanations and his methods to suit the particular group instead of being mechanical and thinking only of himself, his time, and his pay. In brief, you want to be *guided* and *directed*. Also, you must follow the guide's explanations and directions carefully and make the best use of your guide book to get the most satisfaction and value from your trip. Moreover, you will receive just as much as you put in because the guide does not compel you to listen and learn and enjoy unless you voluntarily do so. The guide book will enable you to recall the things which you may forget or to add more to your knowledge.

You will readily see the similarities between our imaginary trip and our course in chemistry. Just as you would find many familiar things in foreign countries although in new and interesting settings, so you will find many familiar things in the field of chemistry but we shall learn many new and interesting things about them—their composition, activity, characteristics, how and why they act as they do, how they are related to our health and welfare. You will note that the "trip" applies to our going into the field of chemistry; the guide book refers to the textbook we shall use; the guide refers to the teacher-guide; and the supplementary material refers to books, motion-picture films, slides, encyclopedias, et cetera. As a teacher-guide, I desire to do for this class just what a good guide would do for the benefit of his particular party. I do not want you to confine yourselves to the words of the teacher-guide and the textbook; but, I want each one of you to explore the realm of elementary chemistry for yourself through the aid of laboratory work, observation, questioning as to the *HOW* and *WHY* of things about you, by frequent use of the supplementary materials available, and according to your various individual interests and desires.

Chemistry is a science, which may be defined as a body of knowledge organized in such a way as to make it of value in the search for truth. Through the study of chemistry, I shall try to help you learn better how to study, by improving your methods of study and solution of problems that you may meet anywhere in life. The method of science will save you time and improve your study of any subject or improve your ability to meet problems after school.

Naturally some of you will become more interested in this subject and some will do a better type of work than others; but there is plenty of opportunity for each one to succeed in the minimum essentials of this course with a reasonable amount of effort. Work to get the most out of the subject for yourself and try to develop a keener interest by honest effort. Don't work for grades as goals in themselves, because they are like the thermometer that

indicates the temperature of the room but the thermometer does not furnish the needed warmth. Let us all work together in finding out these hows and whys and we shall all learn interesting and useful things, even though your teacher-guide has been over the ground previously and can aid you in learning the fundamentals. There is a challenge to each and every one of us.

What are some outstanding divisions of chemistry that we shall meet in our study this year?

A certain amount of knowledge about familiar things comes to us all very early in life. For example, we learn that coal or gas needs air to burn, that iron rusts and silverware tarnishes, that baking powder and yeast are used in cooking, that some water is said to be "hard" and other water is said to be "soft," that food digests in the body, that our clothes are colored with dyes chemically made, that medicines and antiseptics are useful, *et cetera.* Now we desire to learn more about the how and why of these things and their services to us, and also to learn about many new things we have not noticed. An elementary chemistry course may consist of seven aspects:

1. *Study of common substances:* Where they occur naturally and how they are prepared, their important characteristics, uses, etc.

2. *Laboratory experiments:* Preparation of many common elements and compounds and studying their behavior and why they act as they do.

3. *Definitions:* Learning and understanding thoroughly some of the fundamental definitions that we shall need to use frequently.

4. *Laws and theories:* Learning to understand some of the most important ones for our use, and remembering that they are just statements that scientists have formulated after careful observation and study.

5. *Equations:* Learning to use the chemist's "shorthand" to express the actions and results of various experiments, since these chemical equations are much better than words for expressing chemical reactions.

6. *Tests:* Learning to analyze substances to see of what they are made. Tests are especially important parts of chemistry for doctors, food inspectors, water analysis, chemists in industrial plants, etc.

7. *Industrial applications:* Understanding of the interesting and practical facts which show us how chemistry has become the foundation of many modern industrial processes.

What are some of the objectives of chemistry and why is it so important in its contribution to advancement of modern civilization?

1. Manufacture of useful products from raw materials; such as, iron from iron ores, gasoline from the crude petroleum, cloth from wood.

2. Supervision of industry: All important industries are directly or indirectly dependent upon applications of chemical science.

3. Recovery of valuables from waste products; such as, valuable dyes from formerly wasted soft coal products, etc.

4. Preservation of health is the ultimate mission of chemistry. The marvelous achievements in medicine, the treatment and control of dreaded diseases, scientific preparation and preservation of foods, etc.

5. Effective teaching of chemistry to students in our schools. The increasing importance of chemistry and its teaching has been stated as follows by an eminent scientist: "Indeed, it may be said that the industrial advancement of the nation can be judged fairly well by the extent to which chemistry is effectively taught in its schools and colleges." Many other similar quotations might be given here.

> To be without any knowledge of chemistry is to go through life ignorant of some of the most interesting aspects of one's surroundings; and yet the acquisition of some knowledge of the subject is by no means hard. There are any number of books which tell the story in simple language if you do not wish to study the science intensively. On the other hand, all you need is a real interest and a willingness to think as you read.[1]
>
> "What does chemistry mean to me?" said Mr. Narrowhead as he looked at this page, printed with ink made by a chemical process.
>
> As he pushed back his cuff, bleached by a chemical process, and laced his shoes made of leather, tanned by a chemical process, he glanced through a pane of glass, made by a chemical process, and saw a baker's cart full of bread, leavened by a chemical process, and a draper's wagon delivering a parcel of silk, made by a chemical process.
>
> He pulled out his pencil, made by a chemical process, and wrote a reminder in his notebook bound by imitation morocco, made by a chemical process.
>
> Then he put on his hat, dyed by a chemical process, and stepped out upon the pavement of asphalt, compounded by a chemical process, bought a daily paper with a penny refined by a chemical process, and proceeded to the office where he dealt in a certain chemical compound called coal.
>
> "No," he added, "of course not, chemistry has nothing to do with *Me*."[2]

Other interesting everyday applications may be given, if desired, such as "The Chemical Analysis of an Automobile."[3]

What are some of the aims or purposes of our course?

1. To gain a general idea of what may be included in an elementary course in chemistry—we might say a "road-map of the trip we are going to take into the realm of chemistry this year."

2. To develop an interest so we may enjoy and appreciate our journey as we go along in this course this year.

3. To help you to appreciate and acquire the "scientific habit of mind" in solving problems, not only in chemistry but in any subject and your problems in everyday life, by learning to form judgments on actual evidence after careful consideration of all the facts obtainable, thus preparing you for better citizens.

4. To help give you an understanding of the significance and the importance of chemistry in our national life and industries, and to help you to discover whether you have special aptitudes for further work in pure or applied science.

5. To try to give you information of definite service to you in your daily life; and to try to give you stimulation for a more worthy use of your leisure time wherever you may be.

Since an accurate knowledge of chemical principles and phenomena can only come through careful measurements, proper use of chemical apparatus, and a knowledge of some of the simpler laboratory processes and changes that substances undergo during experiments; it seems best for us to turn our attention to the measurement, manipulation of apparatus, laboratory procedures, and chemical and physical changes that substances undergo during these simple processes performed by way of introduction to our course.

As the speedometer on our automobile is necessary to know how fast and how far we are going, as the grocer must have scales for weighing goods, and as the railroad man needs a good watch to keep his schedule, so do we need measures of length, weight, volume or capacity of liquid containers. Hence, we need to acquire at the very start a thorough knowledge of the units of measurement (including both English and metric systems) used in chemistry; we must learn how to use the instruments correctly and to obtain accurate measurements; and, we must learn to understand the very important relation between these various units we use. Hence, the title of our first unit assignment that is given below.

Unit I. Measurement and Chemical and Physical Changes

Purpose of this Unit: To familiarize you with the various measuring instruments and units of measure, and to teach you how to use them to the best advantage; also, to acquaint you with the common laboratory apparatus, manipulation, processes, and the significance of the common physical and chemical changes which you will meet.

Method: All of the work included under 'Minimum Assignment" is to be completed and thoroughly understood by each student in the class in order to obtain a passing grade and credit for the unit. However, anyone may do as much of the "Average Assignment" and "Maximum Assignment" as he desires or can do, and thereby raise his grade from "fair" to that of "good" or to that of "excellent."

Time allowed for this first unit: First 2 weeks of school.

I. *Minimum Assignment.* (Each student must complete all of this.)

A. Measurement: Instruments, Units and Uses.

1. Demonstration talk by the teacher giving a brief historical development of the two chief systems of measurement:
   a. Why the English system became unsatisfactory: too many tables to remember, no apparent relation between units of weight and volume.
   b. Work of the commission to devise a decimal system (metric).
   c. Demonstration of models of units in each system.

d. Explanation of centigrade scale for measuring temperature.
e. Discussion and questions if any points are not clear.

2. Laboratory work in linear measurements in each system:
a. Draw a line on a sheet of paper, divide it into inches.
b. Starting at the left end, measure the line in centimeters as follows: measure 1 inch in centimeters, 2 inches in centimeters, 3 inches in centimeters.
CAUTION: Do not start measuring from end of ruler. Why?
c. Plot a graph using inches as ordinates, and using the centimeters as abscissas. This graph will be very helpful in converting readings from one system to the other. Practice measuring objects in one system, converting to the other by graph; then measure to check your accuracy.

3. Units of Area and Units of Volume or Capacity:
a. Note that the units of area are merely squares of the units of length; units of volume are cubes of lengths.
(1) Optional: Demonstration by use of blocks.
(2) Each student should now measure several objects:
(a) Two dimensions to obtain areas, in each system.
(b) Three dimensions to obtain volumes, in each system.
b. Three dimensions to obtain volumes, in each.
NOTE: 1000 cubic centimeters (cc.) equals 1 liter (L.).
Suggestion: Since many objects of which we wish to find the volume are cylindrical, we have to find the area of the circle which involves this statement—circumference equals "pi" times diameter. What does "pi" mean? Measure several cylindrical objects with a string and also measure the diameter. Now find the *relation between* the circumference (dependent) divided by diameter (variable) in each case. What is relation and meaning of "pi"?
(3) Measure the volume of some of the objects, previously measured by rulers from which the volume was computed, but meaure them now by method of water displacement. Compare your results. Which is the more convenient and accurate method? Why do you think so?

4. Units of Weight:
a. Develop the weight of 1 kilogram of water as follows: (Demonstration) Balance a large breaker on the scales; add 1000 cc. of pure water chilled to 4 degrees centigrade, and balance it by putting on a piece of lead filed down so it will just balance the 1 liter of water. This is known as the weight of *1 kilogram*. It is evident that 1 cc. should weigh 1/1000th of a kilogram, and this small weight is called the gram. Hence, 1 gram is the weight of 1 cc. of pure water at 4° centigrade. It is the unit of weight in the metric system, just as the pound is in the English system.
b. Comparison of weights in the two systems: (Demonstration) Take a spring balance graduated in grams and in ounces and take the readings in grams for each two ounces as far as the scale permits. Plot a graph and continue the line until it reads at least 1000 grams along the gram-axis. Now read the value in pounds. Then check this graphical reading by placing a pound-weight on the balance and get its equivalent in grams. Weigh several other objects in one system, read value from graph in other system; then check by weighing.

5. Unit of Time: the second is the unit in each system.

6. How to use the various instruments for measurements:
a. Rulers: Explanation and demonstration of proper way of applying ruler to a surface; estimating tenths of smallest scale divisions (millimeters); reason for not measuring from end of wooden rulers; care of rulers.

b. Balances: Explanation of structure, care, and use of balances and the weights. Object placed on *left* pan.
c. Weights: Explanation of the kinds, care, uses, how to add and check weighings (by vacant spaces in weight-box and checking again as weights are replaced in the box).
d. Graduated cylinders and Burettes: How to read from the under curved surface of the meniscus; hold level with eye.

B. Apparatus and Manipulation.

1. Apparatus: Exhibit common pieces of laboratory apparatus and explain the names and uses of each. Illustrate line drawings to be used in making drawings of apparatus used.
2. Manipulation:
   a. Glass materials: (Demonstration and explanations)
      (1) Demonstrate cutting and annealing of glass tubing.
      (2) Bending glass tubing with aid of wing-top on the Bunsen burner; rotating to avoid collapse of tubing.
      (3) Cork-boring and inserting glass tubing into the cork; rotating borer; moistening tube; inserting by twisting motion; selecting borer slightly smaller than tubing.
      (4) Inserting tube or thermometer into stoppers; moisten and proceed as in (3) being careful not to push too hard which might break the tube and produce severe cuts; should always use annealed tubing for safety.
      (5) Heating glassware and porcelain: How to heat liquid in a test tube which may be held in flame after the tube and contents are hot; always use wire gauze with asbestos center (or asbestos mats) over the flame when heating beakers, flasks or evaporating dishes. Do not allow flame to come up on these above the level of the liquid surface; heat crucibles gradually at first.
      (6) Placing solids in test tubes: place powder or pieces on small sheet of paper, roll paper and insert into tube in a horizontal position, raise tube to vertical.
   b. Bunsen burner: Explain parts and their uses; note the effects of opening and closing holes; note parts and the shape of flame in each case; when holes are open rub two pieces of chalk together in flame and note result; repeat using two pieces of charcoal and note results; what is the cause of luminosity of flame? Insert glass tube in the center cone of unburned gas and bring lighted match to the opposite end and note results. While holes are all open, reduce the gas supply and note the act of "striking back"; emphasize the *danger* from this incomplete burning. What type of flame is best for general use and why? Explain.

C. Common Laboratory Processes: (Demonstration and explanations).

1. Decantation; filtration; folding filter paper; terms filtrate and residue; suction filtration; distillation; term distillate and testing it with phenolphthalein, etc.; evaporation; precipitation.
2. Materials for demonstration of the above processes: Water, fine sand, pulverized clay, potassium chromate, ammonium hydroxide. Mix together and save for demonstration.

D. Chemical Changes and Physical Changes: (Demonstrations).

1. Conditions that induce chemical changes:
   a. Mechanical means: carefully mix a pinch of powdered potassium chlorate and powdered sulphur on a pice of iron; strike mixture with hammer. result? Repeat with head of a match. Result? Need for *caution* with chemicals.

b. Light: effect on blue-print paper, silver chloride, etc.
c. Electricity: Electrolysis, electroplating, etc.
d. Solution: Mix cream of tartar and baking soda; add water.
e. Heat: Burning magnesium ribbon; heating bright copper; heating a mixture of zinc dust and powdered sulphur; etc.

2. Physical and chemical changes illustrated: (Demonstration) Dissolve some sugar in water and note kind of change; carefully introduce some concentrated sulphuric acid and note color, action and kind of change resulting. Heat a piece of platinum wire and note result; heat a piece of magnesium ribbon and note the kind of change resulting. Heat a small quantity of mercuric oxide gently and cool and note; then heat it intensely for a few minutes and note results.
3. Differences between a mixture and a compound: (Demonstrate)
Mix two grams of iron filings and one gram of sulphur and note the appearance of the mixture. Divide it into three portions. Test one portion by bringing a magnet down very close to it and note result. Test a second portion by adding carbon disulphide and shaking the mixture well; result? Place the third portion in a test tube and heat until it glows; cool, examine, compare, test with magnet and with the carbon disulphide, and note the results. (May test residue with hydrochloric acid and compare results.) You will note that making a mixture is a physical change; while making a compound is a chemical change.
4. Types of Chemical Change:
a. We have noted some cases where we have separated a substance so to produce two new substances. Recall some. This taking things apart to see of what they are made is called analysis, or simple decomposition, and the process may be represented as follows: $AB \rightarrow A + B$.
b. We have noted other cases where we have put two substances together to produce a new substance. Recall some. This putting things together to form a new and different substance is called synthesis, or simple combination, and it may be represented as follows: $C + D \rightarrow CD$.
c. In some other cases we have changed things around and have produced two other substances that are different from the two original ones. Recall some. This changing things around to form a new and different pair of substances is called metathesis, or double decomposition, represented thus: $AB + CD \rightarrow AD + CB$.
d. Another type of reaction may be shown as follows: Fill a test tube about one-half full of copper sulphate solution, drop in an iron nail, and note the results after a few minutes. It is apparent that the copper has been "crowded out" or replaced (displaced) by the iron. This reaction of substituting one thing for another is called Substitution or simple replacement, represented thus: $EF + G \rightarrow GF + E$.

II. *Average Assignment:* (For anyone who has time and so desires.)
1. Construct some wooden or paper models of 1 cubic centimeter and of 1 liter volume.
2. After reading one of the references pertaining to the history of chemistry, write a brief report centering around the following questions: About how long has there been some study of chemistry? (b) Who were the alchemists? (c) Give some account of their work and what problem were they chiefly interested in solving? (d) What are some ways in which modern chemistry differs from ancient or medieval chemistry? (e) What were the four elements which the ancient philosophers discussed?
3. Prepare a list of chief industries of your community (or of your state) and tell which of these industries need chemistry or its applications. Be able to

tell at least one way in which chemistry is related to the ones needing it. Do you find any industries that do not need chemistry or its applications?

4. Bring to class some article pertaining to chemistry that you have found in some current magazine, newspaper, etc.; or, be able to give a report on some topic not previously reported upon.

III. *Maximum Assignment:* (Anyone may do this after completing II.)

1. Look in some of the available laboratory manuals or books and find some experiment (related to our unit) that you would like to perform, begin the experiment and record your data and results for inspection by the teacher. (Note: It would be advisable to consult your teacher before you start experiment).
2. Learn the fundamental principles of the use of a slide rule. (This will be of real assistance to you in your science and mathematics work if you wish to purchase a moderately priced rule for your use. If you plan to go to college or technical school, a knowledge of the use of the slide rule is practical and very often its use is required by such schools.)
3. Optional experiment or topic that you may wish to work out.

Required References for Unit I

Whatever Textbook and Laboratory Manual may be in use at this time.

Supplementary References Suggested

Rose, Robert E. *Chemistry in Industry;* Second Edition, Volume I; 85 Beaver Street, New York City: The Chemical Foundation, 1925. Chapter 1 "Foundations of Chemical Industry."

Caldwell, Otis W. *Science Remaking the World;* Garden City, New York: Garden City Publishing Company, 1925. Chapter 1 "Achievements and Obligations of Modern Science."

Morris, J. *An Introduction to Chemistry;* 8 Warren Street, New York: D. Van Nostrand Company, 1927. Chapter 1 "Early History of Chemistry."

Darrow, Floyd L. *The Story of Chemistry;* Indianapolis, Ind.: The Bobbs-Merrill Company, 1927. Chapter 1 "The Alchemist."

Greer and Bennett. *Chemistry for Boys and Girls;* New York City: Allyn and Bacon, 1925. Chapter 1 (several interesting experiments).

Howe, Harrison E. *Chemistry in the World's Work;* Second Printing; 8 Warren Street, New York City: D. Van Nostrand Company, 1926. Chapter 14 "Chemistry as a Tool," and Chapter 15 "Analysis & Synthesis."

Encyclopedias, Dictionaries, Magazines, Newspaper Items and Pictures, Miscellaneous Textbooks, Laboratory Manuals, *et cetera.*

Chemistry. *Test to be given on* Unit I. Section for Minimum.

1. The metric system is a decimal system of measurement (True, False.) (1)
2. The standard length in the metric system is the *meter;* but the unit of length in the metric system which we most commonly use in our laboratory work and experiments is the *centimeter.* (2)
3. The unit of area in the metric system which we commonly use in the laboratory is the *square centimeter.* (1)
4. The unit of volume or capacity in the metric system which we most commonly use in the laboratory is the *cubic centimeter.* (1)
5. The unit of weight in the metric system is the *gram.* (1)
6. The unit of time in both metric and English systems is the *second.* (1)
7. We might refer to the English system as the "foot-pound-second" system; to metric as "centimeter-gram-second" system. (True, False.) (1)

8. One cubic centimeter of pure water at 4° centigrade weighs *1 gram.* (1)
9. One liter has a volume of *1000 cubic centimeters;* and one liter of pure water at 4° centigrade weighs *1000 g., or, 1 Kilogram.*
10. Using your graphs, answer the following questions:
    a. The weight of 1 Kilogram in pounds is *2.2* pounds. (1)
    b. One pound equals *453.6* grams. (Approximate value allowed.) (1)
    c. Your textbook cover is 5 inches wide; how many centimeters? *12.7.* (1)
    d. Ten centimeters equal how many inches? *4* (1)
11. a. Express 25 millimeters in centimeters. *2.5.* (1)
    b. Express 6.2 centimeters in millimeters. *62* (1)
    c. Add 5.3 centimeters and 17 millimeters and then express the sum which you obtain in centimeters. *7* (1)
12. Physical change means that the form or appearance of substances may be changed but no new substances are formed. (True, False) (1)
13. Chemical change means that the composition of a substance is changed and one or more new substances formed. (True, False) (1)
14. An example of a physical change is: *(Any suitable example)* (2)
15. An example of a chemical change is: *(Any suitable example)* (2)
16. The following are names of common laboratory processes: decantation, filtration, distillation, evaporation and precipitation. In the blanks following the statements below, write the name of the process most likely to be used to separate the substances.

    (NOTE: Do not use the name of any process more than once.)

    a. To separate a mixture of coarse sand and water. *Decantation* (1)
    b. To separate a mixture of alcohol and water. *Distillation* (1)
    c. Process illustrated by result of adding a solution of silver nitrate to a solution of salt and water. *Precipitation.* (1)
    d. To separate water from a salt brine. *Evaporation* (1)
    e. To separate the mud from muddy water. *Filtration* (1)
17. Three conditions very frequently used to induce chemical change are: *Heat, Light, Electricity, Solution (water), Mechanical means* (3)
18. In the first column below are named four types of chemical change; in the second column are literal equations representing each of these types. Write in the parentheses in the third column the *number* of the name of the type which each equation represents:

1. ANALYSIS	$EF + G \rightarrow GF + E$	(*4*)	(1)
2. SYNTHESIS	$AB \rightarrow A + B$	(*1*)	(1)
3. METATHESIS	$C + D \rightarrow CD$	(*2*)	(1)
4. SIMPLE REPLACEMENT	$AB + CD \rightarrow AD + BC$	(*3*)	(1)

19. Mention two advantages of metric system over the English system. (4)
20. Write the number and the name (or names, if there are several parts) of ten of the pieces of apparatus exhibited before you. (5)

Total score (45)

(NOTE: Use back of this sheet for Nos. 19 and 20.)

Section of Test to be given at completion of AVERAGE

21. Bring the models of 1 cubic centimeter and 1 liter volume to the teacher to have them checked for accuracy and workmanship. (5)
22. Present your written report pertaining to history of chemistry to be examined and graded. (10)
23. Present your list of chief industries with the information asked for so the teacher may inspect it and grade it. (10)

24. Bring some suitable current science article pertaining to the field of chemistry, or, give an oral or written report about it. (5)

Total for AVERAGE (30)

Total score for MINIMUM plus AVERAGE (80)

Section of Test to be given at completion of MAXIMUM

25. Present your notebook containing your data, computations and conclusions for the experiment which you performed. (10)
26. Be able to perform some simple calculations on the slide rule as the teacher may direct. (5)
27. Present an oral or written report on some topic or experiment which you have chosen to do. (5)

Total for MAXIMUM (20)

Total score for all three sections (100)

Suggested scheme for evaluation of these tests

1. MINIMUM: Complete all work and pass 75% (or more) of the number of question-points on the test for MINIMUM, that is 75% of 45 points which equals 33.75 points or 34. Grade—75%
2. AVERAGE: Complete all the above and pass 75% of question-points on test for AVERAGE, that is 75% of 30 points which is equal to 22.5 points or 23. Grade—85%
3. MAXIMUM: Complete all the above and pass 75% of question-points on test for MAXIMUM, that is 75% of 20 points or 15. Grade—95%

(NOTE: This may be varied to suit local conditions.)

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The Improvement of High School Physics Teaching By a Regularly Scheduled Unit Testing Program

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Some Important Aspects of Physics Testing

With the coming of the application of the methods of the scientist to the problems of education, the development of objective and reliable tools for the measurement of certain educational products has been inevitable. In the various high-school and college subjects there are now many types of testing and within each field one finds a diversity of tests that is almost bewildering.

Nearly as diverse as the types of these tests are their objectives. There are tests designed to measure certain traits of mentality, tests of aptitude, tests of skill, tests of achievement, tests used for survey purposes, tests of the more intangible character traits, and tests for the improvement of instruction. This discussion is concerned with the last as applied to the field of high school physics.

The early attempts at test building in this field were peculiar in that the tests were designed to cover large blocks of subject matter such as mechanics, electricity, and light. For the most part they were given at the end of a semester or the end of the year, which procedure had many inherent disadvantages from the standpoint of the improvement of instruction.

In the early stages in the development of standardized tests in physics, they were thought to be useful for the following purposes: (1) As a measure of achievement; (2) As a part or total basis for granting marks; (3) For the purposes of investigation; (4) For the improvement of instruction; (5) For purposes of guidance in college courses; (6) In establishing standards for various survey purposes.

The recent tendency is to regard the education of a pupil from the point of view of growth. This growth, to be well rounded and complete, requires a high degree of mastery of the minimum essentials of the several subjects of the secondary-school curriculum. Mastery comes only with repeated experiences. In much of our teaching in the high school today we are teaching and assuming that mastery follows as a matter of necessity. In other words we are most unscientific about our classroom procedures.

Our present methods for finding out what a pupil learns are very cumbersome and unreliable. To a large extent it is the time-worn question and answer method or a variation which is entirely verbal, giving no opportunity for checking up on partially learned essentials. And further, the oral question usually operates in such a manner as to test one pupil on a single item and some other pupil on another. A better method is to get responses from every pupil on every item. The conventional oral method affords little opportunity for the focusing of attention on individual difficulties. In short, our present practice in the matter of checking up on the mastery of essentials is grossly inefficient.

It is obvious that a test which is designed to be given at the end of a course in physics can do little in promoting intellectual growth of a pupil. Such tests are given at a time when the use of the results obtained is usually impossible. Because of the limited sampling of subject matter made necessary by the physical limitations of time for such a test, many of the items in the course remain untested. There is a much greater exclusion than inclusion of subject matter, however scientifically the sampling may be done. These end-of-the-year tests are, however, superior in reliability and validity to the usual essay examinations. Any errors revealed by an end-of-year test remain simply as unmastered items of the course and little can be done about it. Some examples may make this point clearer.

The types of errors that may be revealed by end-of-the-year testing and still remain uncorrected after the final examination may be shown by the following questions from a multiple choice test prepared and used by Glenn in 1922.

Quotations from physics test LP (1922 edition) data based on 387 cases. Test in mechanics given at end of a year of high school physics, nine months.

QUESTION 12. When the weight of a cubic foot of water in a tank is 62.4 pounds, the pressure per square inch on the bottom of the tank due to a depth of water of one foot is, *1.* ( ) 10 lb.; *2* ( ) .43 lb.; *3* ( ) 14 lb.; *4* ( ) 5 lb.

(Forty-five per cent failed to answer this correctly.)

QUESTION 13. The ratio of the load to the acting force (effort) in a machine is called the, *1.* ( ) efficiency; *2.* ( ) moment of force; *3.* ( ) mechanical advantage; *4.* ( ) output.

(Fifty-three per cent failed on this.)

QUESTION 20. In order to warm a pound of water from 32 degrees F. to 212 degrees F. heat energy must be supplied to the extent of, *1.* ( ) 180 calories; *2.* ( ) 180 B.T.U.; *3.* ( ) 99.3 B.T.U.; *4.* ( ) 88 calories.

(Fifty-two per cent failed this item.)

QUESTION 29. When a current of 0.5 ampere is used by a 100-volt lamp, the resistance of the lamp is, *1.* ( ) 16.3 henries; *2.* ( ) 50 ohms; *3.* ( ) 14 ohms; *4.* ( ) 200 ohms. (50)

(Fifty per cent failed on this problem.)

The chief uses of data obtained from an end-of-the-year test then are (1) as a basis for assigning marks, (2) for purposes of guidance in later courses, (3) investigation, and (4) for establishing norms.

The Function of the Instructional Test in Physics Teaching

In the summer of 1922 a most careful study of data returned from four such tests by Glenn given during the school year 1921-22 was made. These data revealed clearly that mid-year or end-of-year testing is almost useless if we hope to realize the chief objective of testing—namely, the improvement of instruction.

On the basis of these data both editions of the four forms of the Glenn tests were discarded in favor of a more comprehensive program of *Topic Tests*. During the school year of 1922-23 the four forms of the Glenn tests were used in a carefully controlled, city-wide survey in one of the large mid-western cities. This work was another attempt to get reliable data upon which to build the comprehensive tests. The results of this investigation were published in 1924 and reveal many valuable points relative to learning in high school physics.*

The data secured from the preliminary testing revealed an additional fact that end-of-year testing, whatever its form, is inadequate from the standpoint of comprehensive sampling of the courses in physics. A study made by Glenn and Brookmeyer gives evidence that the College Entrance Examinations in a range of the nineteen examinations studied, tested only an average of thirty-seven items from the course. With such a small sampling from the two or three thousand items, more or less, taught in a one-year course in high-school physics, the fairness of the sample questions selected as a measure of achievement in physics may be seriously questioned.

A study of the available end-of-year tests in physics, however, shows a much greater range of sampling, generally speaking, than that shown for the College Entrance Board Examinations:

End-of-Year Test	*Total Items from Physics Course*
Test 1	144
Test 2	62
Test 3	125
Test 4	125
Test 5	30
Test 6	30

However, a sampling even as large as these standardized tests show is not known to be adequate to test achievement in the twenty or more units of a subject having so large a body of information, skills, etc., as physics, especially when one takes into account the variability of performance on any particular test. As a device for discovering the specific learning difficulties of a pupil such a small sample is almost useless.

One of the objectives in the construction of the more comprehensive topic tests was to make the samples of subject matter used for a test as large as possible and to include those types of questions which would reveal, in so far as possible, the various aspects of the pupil's growth and not merely his verbal acquisitions.

As has been said previously, the chief justification for any subject-matter test at the present time is its use in the improvement of instruction. It is not the reliable score that we are interested in, mainly, but the growth of the pupil during his experience in physics. It was the chief purpose in the construction of topic tests to invent devices for instruction in physics which would function in checking up errors and improperly placed teaching emphasis, and which would also serve to reveal to the pupil his learning status from time to time and thus stimulate him to greater activity. Some stimulus also comes to the teacher in his desire to know more accurately what and how effectively he is teaching.

When used properly, topic tests insure better mastery of the subject because errors are revealed at a time when there is still an opportunity to reteach points missed by the class as a whole or by individuals. Growth in physics is exceedingly complex and is conditioned by several important factors. An ideal instructional test should reveal weakness and difficulty on the part of the student in as many of these factors as possible. It should check a student's ability to interpret diagrams which occur in text books; should reveal unmastered laws, facts, principles and their applications; should reveal vocabulary weaknesses and any inability to master the technical details of laboratory instruction. Not only should errors be revealed, but the type of error should be shown by the test. It is not sufficient, for example, to assume that the answer to a mathematical problem in physics is the most important aspect of it. Other points are of equal or of greater importance. Can the student analyze the problem, pick out the given factors and the factor to be solved for? Does he know the formula or equation to be used in the solution? Is he able to properly substitute the given factors in this equation and, finally, can he solve for the unknown factor? A problem thus analyzed into its parts can reveal to the teacher the mathematical difficulties encountered by the student and provide the basis for real instruction.

The Use of Tests in the Improvement of Instruction in Physics

Revealing the weaknesses of learning and of instruction at a time when they may yet be corrected seems to be one of the most important factors in raising the achievement of students in high school physics. That this is an important issue has been revealed by the studies of Hughes, Hurd, Glenn and others. To reveal to students at frequent intervals their advancement and the type of errors made is not only conducive to a good learning attitude on his part, but also provides an opportunity for the teacher to institute effective drill programs when and where they are needed.

To make the best use of the results obtained on unit tests some attention must be given to their statistical characteristics. The following suggestions are taken from the Teachers Manual of the Glenn-Obourn Instructional Tests:*

1. Make a distribution of the scores. That is, make a table indicating the number of students obtaining each score.

2. Find the average score of the entire class, either the median or the arithmetic mean. Either measure may be computed from the distribution of scores. Or the median may be obtained by arranging the tests in order according to score and finding the middle score; and the arithmetic mean by adding the scores and dividing the sum by the number of scores.

3. Determine the variability of the scores; that is, the range of the middle half (quartile deviation), middle two-thirds (standard deviation), or middle nine-tenths of the class. These measures of variability are the three most commonly employed for statistical purposes.

4. Express as percentiles the class average, the score of each student and the range (on the basis of the table of norms or of local data). If the student can keep a record of his achievement from test to test as a graph, it will prove a great incentive to more vigorous work on his part.

5. Determine the percentage of the students who fail to answer each question correctly. This may be done in class by calling the numbers of the questions and counting the hands of the students who indicate that they failed to answer each correctly. This incidentally provides one of the best atmospheres for doing really effective teaching that the writer has ever experienced, while this data is on the blackboard before everyone, take up for discussion those questions which were missed most frequently by the class.

When these statistical characteristics have been determined, they may be used very effectively for analyzing the learning difficulties, teaching empha-

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* Instructional Tests in Physics—Glenn and Obourn, World Book Co. Yonkers-on-Hudson, New York.

sis, types of errors, etc. The following suggestions for the use of statistical information in the improvement of teaching are taken from the Teachers Manual of the Glenn-Obourn Instructional Tests in Physics:

1. The teacher may be interested first in how the class as a whole compares with the test norms. The class average (median or arithmetic mean) expressed as a percentile will give him this information. If the class average is equal to a percentile rank of more than 50, it is above the norm. If it is below 50, it is below the norm. If the class average equals a percentile rank of 60, then it is as good as the scores obtained by 60 per cent of the physics students on that test, etc. This comparison gives the teacher a general measure of the mastery by the class as a whole in the unit tested. It is one basis for further instructional practices.

2. In the same way the extent to which the class varies in achievement may be determined by expressing as percentiles the scores which mark off the middle half, two-thirds, or nine-tenths of the class. The extreme cases are eliminated by this method. By a study of the range of scores the teacher can tell how homogenous the class is, what variations are needed in methods and materials of instruction to adjust to the variations among the students, and whether it is advisable to divide the class for special instructional purposes of a remedial nature.

3. The expression of each student's score as a percentile rank will indicate his achievement status and the extent to which he has mastered the unit. The teacher is thus informed of the student's needs, as is the student concerning further work needed on the unit or his readiness for the next unit. This information is more valid if it is in terms of local data based on such classes as are found in the school or school system.

4. If the teacher keeps a record, tabular or graphic, of the class averages (expressed as percentiles) for the test taken, he has a measure of the progress of the class from test to test. The record will indicate the average gain being made; it will show the effectiveness of whatever remedial or drill work has been provided and the need for further special work; and it will provide an incentive to the class as a whole.

5. The student should keep both tabular and graphic records of his percentile ranks. The record will show what progress the student is making and will act as an incentive to him. It will indicate the extent to which he has been helped by whatever special remedial and drill work he has been doing.

6. The data concerning the class and individual scores will provide the teacher with information concerning special drill and review needed by the class or individual students. Further information for this purpose can be obtained from a study of the questions failed or omitted most frequently by the students, informing the teacher, incidentally, in what phases of the unit

his instruction is weakest. The teacher is thus aided in analyzing his instruction so that he can devise better methods when he teaches such phases of the subject again. A detailed analysis of each student's test will show more specifically the items or parts of the unit that he has failed to master.

Some Experiences of Teachers with Instructional Tests in Physics

It may be interesting and pertinent to this discussion to briefly review what some experienced teachers have found after using unit tests. Several teachers were requested to write briefly their reactions to the use of unit tests.

From Miss R. Beatrice Miller of the Overbrook High School, Philadelphia, Pa., formerly of the West Philadelphia High School.

There was always a noted improvement in a term essay examination when separate tests had been marked and discussed in class. In a few cases the crowded curriculum made it necessary for the papers to be marked by myself or student committees. The tests, it seems to me, have demonstrated clearly that the content of the typical one-year physics course is too great to be taught with any degree of thoroughness during a school year with 5 periods per week of 45 minutes each. The achievement would be possible for our bright students but not for the average. The objective test reveals great inaccuracy and lack of thoroughness, due to the fact that the content is too great. Improvement might come, it seems to me, in—

1. Reducing content of course;
2. Working out an adjustable scale for students of different abilities;
3. Insuring a science sequence so that the same class does not contain students having from one to three years of science;
4. Insuring certain mathematical concepts as a foundation.

At first the students did not like the tests, mainly because there were always three or more questions they could not attempt to answer; also because the tests were unfamiliar; also because the tests ask for very definite and accurate knowledge from the student fund of hazy knowledge.

The first difficulty was overcome by explanations of the score and by the grades received for the scores. Once an essay test was given on the same work and the range of scores compared with good correlation.

The students seemed to prefer the multiple choice test. They did not seem to work very hard over the "true-false" test. Some students never attempted the more difficult problems which were always placed at the end. There was no arrangement for giving credit for principle. Frequently the student got only the decimal point wrong.

The students are much interested in the range of scores and in their own rank. It is a definite check on themselves, sometimes encouraging and sometimes discouraging. It is difficult to keep clearly in the mind of the student the difference between an achievement test and an intelligence test.

From Mr. Joseph E. Malin, Swarthmore High School, Swarthmore, Pa.

I have found the physics tests a very inspiring tool for the guidance of physics pupils at the beginning of the course, for the pupils discover from their first experiences with these tests that directions must be followed, otherwise their grades are affected. In the second test on mechanics, the pupil learns to know the importance of labelling the answers to problems, for if he omits the label "lbs. to the sq. in." in one case, the question is marked wrong. The pupil also learns at the start that no announcements

are made concerning the schedule of these tests. He must therefore be prepared at all times for a test and thus not depend on the "cramming process" prior to the tests.

1. The competitive spirit of the class is aroused as its scores are compared with those of the standards and with those of preceding classes. The brighter pupils try to pass the highest previous score made by individuals in the test.

2. These tests surely affect my grading of pupils because the correlation between the summary tests on mechanics and heat and the term averages for the pupils during the first semester has been as high as plus .947 according to the Pearson-product-moment formula.

3. The scoring of the tests in class by the pupils has been the means by which the pupils learn the correct answers to those questions on which they failed. This quite frequently is not the case when the old type tests are given for the pupils upon receiving their corrected papers look at the grades and then throw the papers in the waste basket. The discussions which follow the scoring of the objective tests are the means of correcting wrong impressions gained during instruction. Forearmed with this knowledge of wrong impressions, the teacher can guard against them more carefully in the future. The confusion of the two terms "mechanical advantage" and "efficiency" is a good illustration of this point.

4. An analysis of the tests by means of the per cent of the class answering each question correctly aids the teacher in knowing where to place the emphasis in future instruction and in the reteaching process when this is necessary.

5. When pupils fail on problems in these tests, they are assigned these problems and problems of the same type for homework.

6. An analysis of the wrong answers in the multiple choice test is a direct aid to the teacher in finding the wrong impressions and correcting them. Certain of the multiple choice questions are excellent thought provoking questions because they test the pupil's power of discrimination.

7. Quite frequently there are two or more questions on the same principle or law presented from different angles. This permits the teacher to determine whether the pupils fully or partially understand the point at issue. The two questions in test 8A on the property of water cooled below four degrees centigrade illustrate my point. The questions on writing the formulas for Charles' law and Boyle's law and the two problems on the same laws in the same test furnish another illustration.

8. The practical thought questions in these tests not only arouse the pupils' interest but also they test their ability to apply their knowledge to concrete cases. Furthermore, the teacher has the pupils use this fact as a starting point for gaining more information. For example, the pupil may not only find the answer to the question concerning the range of the clinical thermometer but also he may inform himself further concerning its construction and uses.

9. The pupils prefer these new type tests to the old essay type because the subjective element of scoring is eliminated and also because less writing is required.

10. These tests also contain questions in which the pupil is required to make diagrams of various devices. My criticism of these test questions is not the question asked of the pupil but the lack of more specific directions in scoring such a diagram. If the drawing can be analyzed into several parts, each part that is correct should receive a point credit on the score. The present method is somewhat subjective and I have had difficulty in quite a number of cases in deciding whether to mark the diagram right or wrong.

From Mr. R. J. Coats, Central High School, Detroit, Michigan.

While I do not feel that marks or grades should depend entirely upon tests, my observation has been that in most cases the marks determined by other methods agree very closely with the marks as determined by these tests. A good student in physics will do well on these tests. A poor student in physics, will do poorly on these tests.

While I still favor an occasional essay-type examination for certain purposes, I believe the tests should be used in most cases at least to indicate the rank of a pupil's achievement.

The tests have great value in the improvement of instruction. Many questions which the teacher may take for granted that the pupil knows, are found to be answered correctly by only a relatively small number of pupils. This gives the teacher a chance to improve upon his method of presentation. It also gives the teacher an opportunity to change his emphasis on the various topics. The teacher may in certain cases decide to omit teaching a certain topic entirely.

I find the tests stimulate interest. The students seem to feel they are fair and are more willing to be marked by the results from them than by the results from essay-type. I post on the bulletin board the results made by each pupil and by each class.

Some of the main advantages of the tests are that they are easily administered, easy to score, test a wider range of material, can be used for review purposes, stimulate interest, and are regarded as more nearly fair by the pupils themselves.

Some Questions Concerning Instructional Tests in Physics

1. How can a unit testing program be adapted to a physics course of study where the unit blocks do not correspond with the test units?

2. How may we test for those more intangible outcomes such as attitudes, appreciations, etc.

3. Is time spent in testing as well spent as it would be in instruction?

4. Can students be allowed to score their own tests with satisfactory results?

5. In a program where students are working on the individual plan to what extent is the "passing on" of test information an important matter?

6. Can resourcefulness and other laboratory outcomes be tested with a paper test or do they demand equipment set-ups for reliable responses?

Abstracts

Freeman, Frank N. "A Plea for General Scientific Training in Educational Institutions." *The Harvard Teachers Record* 2:108-116; June, 1932.

The author enumerates some of the changes which have been made in graduate work in education leading to the doctor's degree. Among these he lists the reduction in the residence requirement, the requirement of practical experience, the acceptance of courses in other departments, and the tendency toward abandonment of the foreign language requirement. The author believes some of these changes have been for the better and that others are, at best, questionable. He makes a plea that graduate students be given a broad, general scientific training rather than a narrow specialized, too specific training. —C.M.P.

Stoke, Stuart M., and Lehman, Harvey C. "The Relative Importance of Ability and Industry as Determiners of Scholastic Achievement." *The Harvard Teachers Record* 2:117-123; June, 1932.

Review of educational literature reveals that when teachers rate their students on ability (intelligence) and industry (effort) there is always a positive correlation. When students are rated on the basis of intelligence scores and the number of hours pupils say they study, the correlation is negative. The authors used as one measure in their determination of the correlation between ability and industry, intelligence scores and the number of books taken from the reserve shelf. The authors came to the conclusion that no single answer to this problem is valid generally, because: (1) No generally accepted measure of industry has been developed; (2) Achievement may be so measured as to stress either the fruits of ability or of industry; (3) Composite measures of achievement should take into account the several kinds of ability that determine achievement; (4) The variety of offerings for which college credit is offered is a factor of considerable importance. The greater the variety of offerings the less important is "ability" when measured solely by the ordinary intelligence text; (5) Methods of instruction may be made to favor either industry or ability as determiners of scholastic success; (6) The importance of ability varies inversely with the homogeneity of the student group; the importance of industry varies directly with the homogeneity of the student group. Those colleges which permit almost any high-school graduate to enter probably create a situation in which bright students may survive with little effort. —C.M.P.

Bailey, Edna W., and Laton, Anita D. "The Use of Time by High School Students." *University High School Journal* (California) 12:13-30; May, 1932.

This is a questionnaire study carried out among seventh-grade and eleventh-grade pupils in the University High School. The report covers the activities for a period of seven days. Data were secured on the following items: Time of rising, retiring, hours in bed; regularity and time spent at meals; personal care; method of going to school, time required, and how time was spent before the first class period; number of pupils in gainful employment, kind of work engaged in, and amount of time spent; helping at home; club work; religious organizations; organized activity outside of school such as lessons and practicing; and leisure time. The situation as a whole was found to be most encouraging. There was little evidence of overemphasis on home study, private lessons, home duties, gainful employment, of extra-curricular activities. —C.M.P.

HIGHSMITH, J. H. "Effect of Class Size Upon the Efficiency of Instruction." *The High School Quarterly* 20:165-174; July, 1932.

The article gives a résumé of the important studies which have been made to determine the relative effect of class size upon student achievement. It emphasizes some factors which have been overlooked in many of these experiments, the author coming to the conclusion that nothing has been settled and that our old notion that small classes may be more efficient is probably correct. —C.M.P.

Committee Reports. "Academic Freedom and Tenure." *Bulletin of the American Association of University Professors* 18: 326-405; May, 1932.

This bulletin is devoted to a review of academic freedom and tenure matters, especially for the period 1923-1932, although the period 1915-1922 is briefly referred to. The reports include summaries of cases investigated by the Association. —C.M.P.

HILL, CLYDE M. "A Five-Year Plan for the Professional Training of Secondary-School Teachers." *Educational Administration and Supervision* 18:427-437; September, 1932.

The author considers four main questions: (1) practically and theoretically, what professional equipment is demanded of high school teachers; (2) what is the minimum time required for securing the academic and professional training essential to good high school teaching?; (3) is it feasible and expedient to increase the pre-service training period to five years?; (4) what program of professional training for secondary school teachers seems defensible at this time? The author presents the following arguments in favor of the five-year plan: (1) present oversupply of teacher makes five year plan possible; (2) increased and exacting standards of admission to the profession of high school teaching will raise the professional status of secondary teachers because it will challenge men and women to enter upon training for such service with the expectation of making it a life career; (3) a lengthened initial period will result in better selection and consequently the development of greater teaching skill and professional insight; (4) a probable lessened future demand for secondary teachers as we are reaching or have reached the stabilization point; (5) other comparable professions have long ago found it possible to place professional training on a graduate basis.

The proposed program of professional training would be composed of twelve hours of educational work in the undergraduate school designed to select students for further training and to provide for orientation in educational study. The fifth year would be vocational. —C.M.P.

Science Education in General

WEBB, HANOR A. "The High School Science Library for 1931-32." *Peabody Journal of Education* 10:20-32; July, 1932.

A continuation of Professor Webb's annual review of science literature suitable for use by high school pupils begun in 1925. The relative value of books for high school use is indicated by a price classification as being suitable for inclusion in a 10, 25, 50, 100, or 250 dollar library. Books are classified also in topical groups with short annotations. Prices and publishers are given.

The author indicates these trends among science books, "a popular interest at this time in *exploration*, with volumes that will provide many thrills. Books on health never diminish in number. The flood of volumes on aviation seems to have passed its crest, and radio has settled to the status of a practical everyday science. There seems to be a dearth of 'garden books' this year."

Science teachers should have a complete list of these library lists, now numbering seven. —R.K.W.

LILLINGSTON, CLAUDE. "Pioneers of Medicine—Baron Shibasaburo Kitasato." *Hygeia* 10:798-800; 854; September, 1932.

The outstanding achievements of a pioneer in the field of bacteriology, Baron

Shibasaburo Kitasato, is summarized in this article. The rigorous training in bacteriological technique received in the laboratory of Robert Koch, the celebrated German scientist, equipped Kitasato for the brilliant investigations which he subsequently carried on. In 1889, he isolated the bacillus causing tetanus; found that the organism produced toxin; discovered that when toxin was injected into experimental animals the animals produced antitoxin which neutralized the toxin; and learned that the antitoxin produced was specific in its action. These investigations together with those of Von Behring on diphtheria laid the foundation of our present method of treatment by use of serums.

In 1894, Kitasato and Aoyama found the bacillus of bubonic plague in the blood of a victim of the outbreak of plague in Hongkong. Further investigations relating to methods of transmission and control of plague added information that enables man to fight the disease intelligently.

Kitasato and his students carried on famous research work in the bacteriological laboratory of the Government Institute and later in the Kitasato Institute. He also was instrumental in unifying and organizing the medical profession in Japan. His death in June, 1931, closed the life work of an eminent Japanese scientist in the field of bacteriology and medicine.

—F.G.B.

MYERS, J. A. "Guarding Against Tuberculosis." *Hygeia* 10:818-821; September, 1932.

The author discusses means of guarding against tuberculosis among children. In the past, much thought and care has been given to those who have had the disease but little attention has been accorded the non-infected child. The knowledge that tuberculosis develops only in the presence of tubercle bacilli indicates the first step in controlling the disease, namely, preventing the organisms from reaching the body. Control of tuberculosis involves provisions, such as the following: proper kinds of food in ample amounts; air in homes and schools that is free from foreign matter and that has the proper temperature and humidity; production of sufficient energy through the use of food; and the regulation of the energy by means of rest during the day as well as at night. The use of vaccine B C G by Calmette as a means of immunizing children against tuberculosis is briefly discussed.

The author states that the nation's greatest hope lies in health education through the schools. He suggests that possibly due to insufficient teaching children have not learned the ways in which the body can be made healthy and be kept in a healthy condition. —F.G.B.

PAYNE, V. F. "The Lecture—Demonstration and Individual—Laboratory Methods Compared." *Journal of Chemical Education* 9:1277-1294; July, 1932.

This is a partial report of an experimental study carried out with 299 students in twelve sections of general college chemistry in four different colleges, involving five different instructors. Six sections were taught by the lecture-demonstration method and six sections by the individual-laboratory method. Standard chemistry aptitude and training tests, ordinary examinations, and teaching grades were used in comparing the groups. The study did not produce uniformly significant results, but tended to favor the lecture-demonstration method. Students seemed to make better progress when introduced to college chemistry by the lecture-demonstration method. Women students made relatively better use of the individual-laboratory method than did the men. —C.M.P.

KAMM, OLIVER. "Chemistry and the Quest for Health." *Journal of Chemical Education* 9:1719-1729; October, 1932.

This article traces the quest for health from prehistoric times to the present. The author presents the following classification of diseases, based on the progress made in methods of treatment: (1) diseases which can be controlled by general public-health measures; (2) diseases which can be controlled by the use of drugs either by prophylaxis or by direct treatment; (3) diseases which are partly controlled by drugs; (4) diseases for which we have as yet inadequate preventives or cures, although symptomatic treatment with drugs is often of great value in building up natural resistance to infection and in giving

relief; (5) diseases of middle age, for which treatment with drugs is mainly palliative, but usually of great value in prolonging life; (6) growth disturbances.—C.M.P.

HANSEN, H. W. "Sources of Project Material." *Journal of Chemical Education* 9:1078-1086; June, 1932.

Numerous sources of project and exhibit material that may be secured from industrial concerns are listed in the article. Brief descriptive notes are included.

—C.M.P.

NICHOLS, M. LOUISE. "Courses in Science, Shall They be Specialized or Unified." *School and Society* 36:147-149; July 30, 1932.

The author presents the thesis that specialized courses in science such as biology, physics and chemistry do not conform readily to the mental development of high school boys and girls. At the same time relatively few pupils will continue these specialized science courses in college, so the author makes a plea for an advanced unified science course at the high school level. The author would present topics relating to social progress such as: evolution, heredity, molecular and atomic structure, communication, electromagnetic waves, etc.

—C.M.P.

Science in Grades Seven, Eight, and Nine

TURNER, F. W. "An English Impression of American General Science." *School Science and Mathematics* 32:585-595; June, 1932.

An interesting article as indicated by its title. The impression is the result of a five-month's inspection of American classes in general science and teacher-training institutions preparing general science teachers. Mr. Turner believes that general science in America leaves much to be desired primarily because teachers are not adequately trained for teaching it. Our great enthusiasm for universal education and our tendency to follow fads comes in for a share of criticism. The wide practice of written and oral pupil reports receives most favorable mention. —A.W.H.

RODEAN, WILLIAM A. "Overlapping of Content in Textbooks in General Science and Biology." *School Science and Mathematics* 32:605-613; June, 1932.

This article presents evidence on some overlapping in courses in science. It is important because of its bearing upon the question of the development of a real sequence of courses in science—something which we cannot yet pretend to have.

—A.W.H.

SHIRAS, GEORGE. "Wild Life of the Atlantic and Gulf Coasts." *National Geographic Magazine* 62:261-309; September, 1932.

A field naturalist's photographic record of the animal and bird life of the Atlantic and Gulf coasts. There are sixty-two illustrations. —C.M.P.

WETMORE, ALEXANDER, and BROOKS, ALLAN. "Seeking the Smallest Feathered Creatures." *National Geographic Magazine* 62:65-89; July, 1932.

The first of a comprehensive series of paintings and descriptions of all the important families of birds in North America. About 500 familiar land and sea birds will be depicted. In this series humming birds, swifts, and goatsuckers are portrayed. There are 44 illustrations, including 35 portraits in color. Life histories are included. —C.M.P.

WESTWOOD, RICHARD W. "Birds of the States." *Nature Magazine* 20:168-172; October, 1932.

This article presents, with colored photographs and brief descriptions, the various birds that have been officially designated as the official avian emblem. Four states, namely, Connecticut, Indiana, Iowa, and New Jersey, have not an officially designated bird. —C.M.P.

BURTON, WALTER E. "Treasure Hunters Comb Earth for Priceless Plants." *Popular Science Monthly* 121:34-35; 112; August, 1932.

An illustrated article describing how men like Dr. Fairchild and the late Frank N.

Meyer of the United States Department of Agriculture seek out plants in foreign lands, looking to the ultimate use of some of them in the United States. —C.M.P.

Science in Senior High School

CAHOON, G. P. "Planning to Teach a Unit of Physics." *University High School Journal* (California) 12:66-78; August, 1932.

In this article the author very forcibly emphasizes the point that in high school physics we are teaching students and not physics per se. He lists as the five main steps in planning a unit in physics: (1) To list the specific objectives; (2) To lay out the major activities and topics for the realization of these objectives (the large unit plan). (This includes the listing of demonstrations, of laboratory experiments, and of special reports by students); (3) To set down a day-by-day schedule; (4) To make out daily or detailed plans, indicating specifically how the major activities and topics are to be directed and carried out; (5) To prepare the necessary study guides, bulletin board and pamphlet-material questions, laboratory quizzes, slides, charts, etc., and the final unit examination.

The time schedule for a year's work in high school physics is included. A detailed analysis of the unit "Air and its pressure" is given as an illustration of how the plan is worked out. —C.M.P.

WADE, FRANK B. "Chemistry as a Vocation. A Bit of Vocational Guidance for Inquiring High School Students."

RHODEHAMEL, H. W. "Chemistry as a Vocation. Your Start Toward an Industrial Job in Chemistry." *Journal of Chemical Education* 9:1058-1064; June, 1932.

These two articles describe the vocational opportunities of the student specializing in chemistry, describing the types of jobs, the pay, the unique requirements for success, etc. —C.M.P.

GARRISON, K. C., and TAYLOR, R. A. "Botany Materials in Four Well-Known Magazines." *Peabody Journal of Education* 10:87-91; September, 1932.

The analysis is based upon the five years' issues, 1925-1930, of the *Literary Digest, National Geographic Magazine, Saturday Evening Post,* and the *American Magazine.* Findings are summarized in terms of a standard page for these four magazines. Plant groups of greatest importance according to the study are flowers, 138.37 pages; cereals, 108.00 pages; forests, 89.2 pages, and fruits, vegetables, cotton, rubber, and forage ranging from 64 pages down to 11 pages. The treatment of bacteria ran only 1.3 pages. Topics about plants most frequently treated were breeding, budding, grafting, habitat, estimation and production, utilization, names, and physiology, in the order here given.

The reader may well question this type of study as a sound basis for selecting materials for a high school botany course upon two points. The average investigator would scarcely turn to such periodicals as the *Saturday Evening Post* and the *American Magazine* for materials within the field of botany. Assuming the selection of sources, the basic philosophy of such a study may be questioned on the assumption that the things that are discussed in magazines are the things that *should be* discussed or taught. —R.K.W.

AARON, S. F. "The Muscular Power of Insects." *Scientific American* 147:148-150; September, 1932.

This rather unusual article on insects as machines discusses the kinds of levers found in insects and their relative efficiency as machines. The author states that in all animal life there are no muscular levers of the second class. Many insects are remarkably efficient as machines. —C.M.P.

SYMPOSIUM. "Chemistry Club Organization." *The Chemistry Leaflet* 6:1-32; September 22, 1932.

Not only will chemistry teachers who have chemistry clubs find this number of the *Chemistry Leaflet* very practical and useful but all teachers of science who sponsor science clubs would greatly increase the usefulness of their club work by reading and following out the suggestions offered

in the leaflet. It is devoted entirely to suggestions for the Chemistry Club.

—C.M.P.

PETTIT, DONALD D. "Organization of Science Clubs in the High School." *Journal of Chemical Education* 9:1260-1267; July, 1932.

The objectives, principles of organization and conduct of high-school science clubs are discussed in this paper.

—C.M.P.

KAEMPFFERT, WALDEMAR. "Atomic Energy—Is It Nearer?" *Scientific American* 147: 79-81; August, 1932.

The author discusses the progress that has been made in investigating the structure of the atom and more specifically the possibilities of tapping the large reservoirs of atomic energy. Especial attention is paid to the work of the young English physicists, Cockcraft and Walton. A picture of the R. J. Van de Graaf apparatus that is being constructed for the Massachusetts Institute of Technology is included. The apparatus will produce 10,000,000 to 15,000,000 volts and should result in obtaining some interesting information about the structure of the atom. —C.M.P.

CROWTHER, J. C. "And Now the Neutron." *Scientific American* 147:76-78; August, 1932.

In this article the author reviews the history of researches leading to the discovery of a different type of matter—the neutron. The idea that such a type might exist was first advanced by Rutherford. During 1931 Chadwick of England and Mme Curie—Joliot (daughter of Mme Curie), and her husband M. Joliot independently investigated the element beryllium. Results of these studies seem to indicate a new type of matter, now called the neutron, which consists of one electron and one proton with a zero nucleus charge. It differs from the hydrogen atom in that the electron and proton are quite close together—a sort of a condensed hydrogen atom. Much investigation concerning the nature of the neutron and its relation to the evolution of matter will probably occur in the future. —C.M.P.

TURRILL, PARK LOVEJOY. "Studies in the Mineral and Chemical Resources of the Mojave Desert." *Journal of Chemical Education* 9:1319-1339; 1531-1552; August, September, 1932.

This article presents the amazingly large quantities of minerals found in the Mojave Desert of southern California and Nevada. Ninety per cent of the approximately 2000 known minerals are rare, but a very generous percentage of these are found in this desert. The desert, once considered worthless, is proving to be "America's Chemical Storehouse." Illustrated. —C.M.P.

ENGLE, DOROTHY G. "The Names of the Elements." *Chemistry Leaflet* 6:30-32; September 29, 1932.

The elements are grouped into eight classes according to the derivation of their names: (1) Properties; (2) Geographical locations; (3) Colors; (4) Minerals; (5) Heavenly bodies; (6) Long-known compounds; (7) Mythology; (8) Unknown or uncertain. The origin of the names is shown for each element. —C.M.P.

New publications

WHITMAN, WALTER G. *Household Physics.* New York: John Wiley and Sons, Inc., 1932. 502 p. $2.75.

The book in practical physics has been brought up to date both by the revision of many chapters and the addition of three new ones. It should prove useful as a textbook for classes of girls either in general courses or in home economic courses. Teachers of other physics courses will find the book an excellent supplementary text and reference book. There are approximately four hundred illustrations together with numerous exercises and experiments suitable for both demonstration and laboratory work.

The author has had considerable experience in the training of science teachers and the knowledge thus gained has been set forth in this book. —C.M.P.

PIEPER, CHARLES J., BEAUCHAMP, WILBUR L., and FRANK, ORLIN D. *Everyday Problems in Biology.* New York: Scott, Foresman and Company, 1932. 686 p. $1.60.

As its name implies, this book deals with the biological problems which pupils meet and seek the solution of every day of their lives. They are not the problems which some college professors and high school teachers think one should solve in order to pass the college entrance examination, but they are problems of life—of living things—asked daily by the pupils themselves.

From their wide experiences with pupils of the high school level, these authors have produced a book which is suitable for all biology pupils of the secondary schools. Not only is there material for below average and average pupils, but at the end of each unit there are additional exercises of sufficient difficulty to keep the cleverest working to his maximum capacity.

Twelve major units are developed from such topics as Nutrition, Growth, Adaptation, Interdependence, Behavior, Man's Work with Other Living Organisms, and The Conservation of Human Life. The subject of each unit is in the form of a question, and the whole unit is developed according to the "unit-problem" plan of science teaching. The Preliminary Exercises at the beginning of each unit are good pre-tests which might also be used as general review exercises. The presentation, which is in story form, is so developed that each new step suggests a number of questions to be solved before the unit is completed. Study suggestions, explanations, experiments, suggested activities and an excellent bibliography and reference guide provide sufficient material for the periods of assimilation and organization.

The language is as non-technical as that of the scientific books and magazine articles prepared for the adult layman. Whenever a new term is introduced, the authors have spared no pains to explain it in such a clear, definite fashion that no high school pupil could fail to grasp its meaning. As further aids a Glossary and Pronunciation List are found at the back of the book.

The young teacher will find much help in it in the days when he needs something to guide his uncertain steps, and the older teacher will discover that here is something which will lift him out of the rut of dead structural botany and zoölogy and place him in the broad and interesting path of living biology. —G.B.H.

WATKINS, RALPH K., and BEDELL, RALPH C. *General Science for Today*. New York: The Macmillan Company, 1932. 653 p. $1.68.

The authors have done quite well what they promise in the preface—"to present a continuous, uninterrupted story of science as it has affected mankind on the earth." In the last two units—units XIII and XIV—the authors direct particular attention toward science as a field of knowledge and intellectual activity with the evident purpose of stimulating pupil interest in its better use. The titles of these units are, "Important Ideas That Have Contributed to Man's Control of His World" and "Solving the Problems of Natural Science." In Unit XIII, the pupil is introduced to the recent discoveries in science; in Unit XIV the student is led to see what scientific thinking is and how it contrasts with superstition and belief not founded on fact.

The fourteen units include thirty-four chapters. Each unit is introduced by a list of the problems to be considered in the unit, and a statement of what the pupil may expect to find in the unit. At the end of each chapter is given a list of required learning activities, and a second list of optional learning activities. At the end of each unit is given a list of unit organizing activities, a summary of facts and principles to be remembered, and a list of suggested readings.

The book should prove useful when considered as an orientation to the specialized sciences. It actually touches upon most of the interesting and vital topics in science, and gives the pupil a general conception of what the various pure and applied sciences are. Whether it will lead pupils to a further study of science or satisfy them in their curiosities so that they will not care to investigate further details can be determined only by experiment. This is a question which arises when any general science textbook is discussed. No doubt, if a pupil really mastered and applied the material presented, he would be able to live on a fairly high plane compared with the present day life of the masses. The book should also be useful to the pupil who does not study organized science further and to the layman who wishes to get an overview of science in general. —A.W.H.

HUNTER, GEORGE W. *Laboratory Problems in Biology*. New York: American Book Company, 1932. 325 p. $0.60.

This book supplies work for the pupil to do in connection with the author's "Problems in Biology" (reviewed in *Science Education*, April, 1932). The contents follow the same unit arrangement. Each exercise has a pre-test, many self-testing exercising, space for review summary and a test on fundamental concepts in the unit. Provision is made for all types of demonstrations, practical exercises, field exercises, extra problems, and supplementary reading. There are outline drawings to be filled in and labelled, as well as outline tables, so that pupils may make concise summaries of their work.

This is an excellent workbook made to accompany an excellent text. It could not be effectively used to accompany another text. —C.M.P.

WHEAT, FRANK MERRILL, and FITZPATRICK, ELIZABETH T. *General Biology*. New York: American Book Company, 1932. 566 p. $1.60.

The authors have prepared this book "for those students who have had a course in General Science or in Elementary Biology." It is also designed as a "basic text for the New York State syllabus in General Biology and similar syllabi." In these respects it does differ from some of the biology texts that have appeared recently. The content does not seem to exceed in difficulty that of many contemporaneous biologies but rather it seems to take its departure in the nature of the subject matter itself. This is undoubtedly intentional, but is not emphasized in the preface.

There are forty-six chapters divided into eleven units as follows: Man is one of millions of species; there is unity among living things; nothing is as unchanging as change; self-preservation depends upon nutrition and protection; living things are interrelated; life is a variety of adjustments; reproduction is the means of race preservation; race modification is the result of variation and heredity; man controls and improves his environment; man

makes use of biological discoveries to promote health; man has progressed through the centuries.

It is a very readable book, written in a style that should appeal to the student. Its appearance and usefulness is enhanced through its many well selected illustrations. The reference list is somewhat inadequate especially for a book of this sort, presumably built upon a previous course in biology and for advanced students. There are so many excellent books, especially popular books for pupils and teachers who might use the book, that have not been listed.

In addition to being a commendable text, the book should serve as an excellent reference book for teachers of biology, general science, and elementary science.

—C.M.P.

Fuller, Robert W., Brownlee, Raymond B., and Baker, D. Lee. *First Principles of Physics*. Boston: Allyn and Bacon, 1932. 812 p. $1.35.

This is a revision of an earlier edition by the same authors. Owing to the "wishes of many teachers," the revised edition is more in accordance with conventional practice than was the earlier edition. The subject matter of what is commonly called mechanics of solids has been placed next after that of mechanics of fluids whereas in the earlier edition it was placed nearer the end of the book after chapters on electricity and magnetism. Undoubtedly the authors' judgment was that mechanics of solids deals with more difficult material and should therefore come later.

The book includes thirty-nine chapters —a greater number than any current textbook of high school physics. Apparently the authors believe in a more intensive treatment and more distinct emphasis of certain topics than is usual. This makes the book the most voluminous current textbook in high school physics. It is not objectionable to teachers who do not follow a textbook too slavishly. It results in less need of supplementary references which may, however, keep pupils from forming the good habit of consulting other authors. Each chapter has a summary and a great variety of exercises including problems and thought provoking questions. Other pertinent questions are interspersed at suitable intervals. At the end of each series of chapters bearing upon the conventional divisions of physics, new type test questions of several varieties are given. These tend to unify the content of the specific chapters into larger wholes. The wealth of illustration is a noteworthy feature of the book.

The treatment of subject matter is a good compromise between academic and practical. Applications of physical principles are given considerable prominence but the organization is around abstract generalizations primarily. New developments in the field of physics are given due attention with a particular lean toward physics in everyday life in the last few chapters. Radio, television, talking-pictures, water power, the automobile, and the airplane are discussed in the last three chapters.

Altogether the book shows careful preparation and much labor by the authors. It should prove a useful text particularly adapted to city high school pupils. The authors have had long experience in teaching pupils in a large metropolitan high school.

—A.W.H.

Stewart, Oscar M., Cushing, Burton L., and Towne, Judson R. *Physics For Secondary Schools*. Boston: Ginn and Company, 1932. 736 p. $1.72.

According to the preface, the authors have attempted (1) to simplify usually difficult topics and omit very difficult ones; (2) stress applications of physical principles; (3) make the book interesting so as to properly motivate pupils; (4) clarify principles by presenting many specific facts bearing upon the principle; (5) provide teaching aids in the form of introductory chapter questions, objective thought questions, and problems; and (6) designate the less important sections by asterisks. In addition, either as an afterthought or because of considered relative unimportance not worth mentioning in the preface, they have written introductory pages for the larger conventional sub-divisions, with the evident intent of showing how these divisions may be integrated about the general topic of physics as a study of energy transformations. These conventional divisions—mechanics, heat, sound, light, magnetism, and electricity—

are given slightly different names and designated as units, although no real organization of teaching activities about these units is noticeable other than the introductory page referred to. The organization is more nearly a chapter organization. At the end of each chapter is a summary of important concepts treated in the chapter, questions, in most cases problems, and rather detailed suggested queries for investigation apparently intended for supplementary work. There are 576 illustrations in the book.

An examination of the book makes it appear that the authors adhere in general to the conventional organization of subject matter in physics. Whether the explanations and descriptions are clearer than those found in current textbooks can only be determined by experiment and objective measurement of pupil achievement. The last Unit, "Electrical Emissions and Waves" serves to bring the book up to date in the matter of introducing the pupil to recent physical discoveries. In spite of the statement of the authors concerning the growing importance of the scientific study of sound, but 7% of the book is given over to this subject. This is almost identical with the practice of all current textbooks in physics.

The authors should be commended for their attempt to help pupils understand physics better, but that their activities have been considerably restricted is made clear by their statement in the preface, "The book, however, fully meets the requirements of the College Entrance Board and other standard requirements." In a nutshell, this statement explains why textbooks in physics continue to follow so conventional a pattern. —A.W.H.

HUNTINGTON, ELLSWORTH, BENSON, C. BEVERLY, and MCMURRY, FRANK M. *Living Geography*. New York: The Macmillan Company, 1932. Book I, 346 p. $1.20. Book II, 506 p. $1.60.

One has only to critically examine this series of geographies to come to the conclusion that textbook writing in the field of geography compares favorably with that in any other field. These books serve to emphasize the fact that much progress has been made in geography textbook writing. They are superior in every way to geographies of five or ten years ago—new teaching devices, techniques and approach—even the subject matter is different and better.

Book I, uses the historical method of approach. Beginning with the United States and passing from nearby to more distant countries, it emphasizes the rural and village life of each country—the "how" in geography. Book II, uses the causal method of approach, emphasizing urban and industrial life—the "why" of geography. One book is elementary, the other advanced. There is no repetition in topics, treatment or viewpoint. Climate is emphasized as a basic factor in geography throughout the two books.

Pupil guides for study tests, keyed references, lists of projects and activities, maps, pictures and statistical matter—all combine to make excellent textbooks both from the standpoint of the pupil studying them and from the standpoint of the teacher teaching them.

It would be difficult to choose a group of three writers better equipped to write an excellent geography textbook. The selection is a most fortunate one. Dr. Frank M. McMurry of Teachers College, Columbia University, long an authority in the field of elementary geography, is also, even better known in the field of elementary education and methods. His knowledge of the elementary school child and elementary school methods is made evident through the "teachability" of the series. Dr. Ellsworth Huntington of Yale University, a geographer of world renown, has contributed his intimate and extensive knowledge of the geography of the various countries of the world. C. Beverly Benson, formerly of Purdue and Cornell Universities, has contributed his knowledge of industrial geography. He is especially responsible for the excellent statistical work. In gathering material for these books the authors traveled more than 250,000 miles and spent more than three years in these travels. All countries were visited by at least one author, many countries by all three authors, and most countries by two authors. As a consequence this series of books is based on much first hand information and experience.

Many features deserve especial comment, but space does not permit. The books live up to the best thought in education by emphasizing visual education through the medium of hundreds of excellent illustrations. The reviewer knows of no textbook in which the pictures are so numerous and so clear and plain. The comments below each illustration add much to their value as teaching devices. They form a part of the subject matter itself and are not extraneous to it.

A series of twenty-eight colored maps in Book I, and thirty-eight in Book II, add much to the usefulness of the books. These series are found grouped together in the back of each book. They are unusual maps both as to color and quality and the amount of information contained.

The statistical equipment is most complete and up-to-date. The reviewer found the graphical summary of world production and consumption unusually interesting. Over 200 countries, states and colonies are represented.

"Living Geography" is aptly named—for it will prove to be a real vital geographic experience in the lives of many thousands of boys and girls for years to come. —C.M.P.

Tobey, James A. *Cancer*. New York: Alfred A. Knopf, 1932. 313 p. $3.00.

Cancer is one of the most dreaded of all diseases. Annually it accounts for over one-hundred and twenty thousand deaths in the United States, and its toll is gradually increasing. This, in view of the fact, that much progress has been made in the technique of diagnosis and treatment, that vast sums of money have been expended in research, and that the lay public is more "cancer conscious." Recent studies show that the increase in cancer cases during the last two years has been approximately equal to the increase during the preceding ten years. Admitting that better means of diagnosis and an increased tendency on the part of laymen to submit themselves for examination, might account for slight gains, the fact remains that there has been a large absolute gain. For reasons as yet unexplainable cancer is on the increase. Medical men agree that if ignorance regarding cancer were not so widespread, perhaps a quarter of the cancer fatalities might be avoided.

The complete title of the book is "Cancer, What Everyone Should Know About It." The book does precisely what its subtitle claims. The book explains the nature of cancer and what cancer is not; relates its history; discusses the various types and locations of cancer and their danger signals; the developments, heredity and contagion of the disease; its causes and treatment, its prevention and control; various cancer cures and false cures; and the anti-cancer movement. An interesting chapter is devoted to persons who have had cancer. Many misconceptions regarding cancer are made clear. As ignorance does not make one immune from cancer, this book should be of interest and value to every science teacher both personally and as a means of promoting the health objective of their science teaching. —C.M.P.

Howard, L. O. *The Insect Menace*. New York: The Century Company, 1931. 340 p. $3.50.

In this book insects are revealed as man's chief rival for the dominance of the earth. That insects are a real menace and that the outcome of the fight between man and insects will result in an ultimate victory for man is by no means a foregone conclusion. It will take all the ingenuity—all the scientific knowledge and weapons at man's disposal to win this fight to prevent his ultimate annihilation.

Dr. Howard reveals that insects have had 12,000 times the chance that man has had to evolve a persistent type and as a consequence, if left to themselves, have a much greater chance of survival than man. Some of the natural advantages of insects are: greater antiquity, small size, power of concealment, rapidity of motion, and particularly the power of enormous multiplication. Man's present civilization and its methods are helping insects to increase and spread. The insect loss in the United States each year is approximately $2,000,000,000 accounting for a 22 per cent loss in wheat, a 20 per cent loss in fruits and a 10 per cent loss in animal products.

The author is by no means pessimistic as to the outcome because he sees the world slowly awakening to the seriousness

of the insect menace. He describes the growing use of chemicals, airplanes, quarantines and variations in crop practices as devices in the combat against insects.

Dr. Howard is former Chief Entomologist of the United States Department of Agriculture. He writes interestingly and well, using a conversational style that should appeal to most readers. The book is recommended for the high school biology shelf—in fact so important is the subject and so well is it discussed that biology teachers would not go far amiss in requiring it as one of the books on the required reading list. —C.M.P.

HARDING, T. SWAN. *The Degradation of Science.* New York: Farrar and Rinehart, 1931. 386 p. $3.00.

It is with mixed feelings that one puts aside "The Degradation of Science" when he has completed reading it. One feels somewhat baffled, pessimistic, chagrined, and ashamed, if he is a devotee of science. Who is honest, what is the truth, who are true scientists? And science that holds so much of truth and offers such great possibilities of leadership and for the betterment of mankind—to see it being put to such degrading ends and abuses, occasionally, even by the very scientists themselves who help produce it, is, indeed, most discouraging. With a surgeon's knife, Mr. Harding lays bare to the bone the shams, the dishonest, the trickery in our professional and business ethics. General education, universities, social science, the law, newspapers, chemistry, politics, advertizing, the church, business—all come in for a severe chastizing. The author treads on many toes. Even scientists themselves do not escape. Woe be to the scientist who steps into another field and offers himself as an expert in the new field or even in his own field, unless he has his facts at hand and up to date. Millikan, Dorsey, Clendenning, Sherman Davis, Fishbein, Eddington, East, and Wiggam are among those to whom Mr. Harding pays his respects. Leaders in other fields do not escape. Big business controls the schools, the press, the church, and science. It sees that the people get the "right kind" of advertizing, and "yes-yes" school-men, clergymen and journalists! The profit-motive that dominates so many phases of American life is held up to ridicule and scorn.

One may not agree with all that Mr. Harding says (and the reviewer does not), but his book is calculated to make anyone who reads it think. If only he had suggested a remedy! It is so easy to criticize! —C.M.P.

MASON, GREGORY. *Columbus Came Late.* New York: The Century Company, 1931. 341 p. $4.00.

"Columbus Came Late" is a popular presentation of the story of the civilizations of North, Central and South America during the "pre-Columbian" period. The author tells the story of the ancient civilizations of the Mayas, Incas, Pueblos, Aztecs, and Toltects. These civilizations were contemporaneous with the civilizations of Europe and Asia and in many respects were superior to any of them.

The author maintains that far too little attention has been paid to pre-Columbian America. As he puts it, we have an inferiority complex that would be eliminated had we adequate knowledge of the great civilizations that once flourished on our shores. The Mayas excelled in astronomy, art and mathematics. They had an astronomical observatory before Europeans; they had independently discovered the zero (even the Romans and Greeks with their many cultural accomplishments had failed to make the zero a part of their numerical system) without which not much progress in physical science would be possible. The Mayas had a calendar superior to the one we now use. They could fix the position of any date in a period of 374,400 years.

It is only comparatively recently that attention has been focused upon these ancient centers of American culture. Many lie buried in a Central American jungle so dense that excavations are made only with difficulty. Some of these ancient cities have only recently been discovered and it is even probable that some remain yet to be revealed. Much remains to be discovered about these cities—the origin of the people, how they were able to develop great civilizations in places now very undesirable, how they lived, their history, the causes for their decline, etc. Much of this

would be revealed if we were able to solve the riddle of the Maya Hieroglyphs.

The author, who was a member of the Mason-Spinden Maya expedition, tells us what is known about each of these pre-Columbian centers of civilization. The Mayan cities were agricultural cities, vegetable fed, built by business men and ruled by astronomer-priests. The Aztecs were great military people—the Germany of their day. The Incas had the world's most successful experiment in socialism: the Pueblos were pacifists; and the Toltecs had the world's first basketball courts. Considerable attention is given to the agricultural contributions the Americas have made to the world. The author stresses his conviction that all these great early American cultures were native and that they owed nothing to Europe. —C.M.P.

PAUL, J. HARLAND. *The Last Cruise of the Carnegie.* Baltimore: The Williams and Wilkins Company, 1932. 331 p. $5.00.

The Last Cruise of the Carnegie is a travelogue of the final cruise of the famous non-magnetic vessel, Carnegie, owned and operated by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. The human rather than the technical aspects of the cruise are emphasized, although the latter are by no means excluded.

The Carnegie was a ship unlike any other that ever sailed the seas. The vessel was built of white oak and yellow and Oregon pine. Copper and bronze were used in all her fittings. Her anchors, her engine and propeller shaft, even the galley ranges were of bronze. Although built by money contributed by Andrew Carnegie, the "steel king," steel was the one thing avoided in its construction.

The seventh and what proved to be the last cruise differed from the preceding intensive investigations. This last cruise, in addition to the usual magnetic survey, included an exploration of the atmosphere and more especially the ocean depths for physical, chemical and biological conditions. The last cruise began May 1, 1928, and ended abruptly and tragically in Apia Harbor, Samoa, November 29, 1929. Following a series of explosions, the vessel was burned and Captain Ault and a cabin boy lost their lives. In addition to this tragic loss was the destruction of valuable scientific data collected on the trip.

This is a story of a fascinating endeavor, and not a narrative, for technical scholars. It is a story of the activities of men who do things—the kind of a story high school boys, and girls, too, will enjoy. It is a book that has a place on the vocational guidance shelf. There are almost two hundred illustrations. —C.M.P.

MCSPADDEN, J. WALKER. *To the Ends of the World and Back.* New York: Thomas Y. Crowell Company, 1931. 362 p. $3.00.

The subtitle of this book, Scouting for a Great Museum, indicates the nature of the book. It contains the stories, told in their own words, of fifteen field men connected with the American Museum of Natural History in New York. They have gone literally to the ends of the world and back to obtain materials for their panoramas of animal life. The author quotes Dr. Henry Fairfield Osborn as saying, "If I were to sum up a field man's creed in one word, I should say it was persistence." Each of the fifteen stories add emphasis to this statement.

Henry Fairfield Osborn tells about the early days of the museum, how he became interested in the work, and about some of the men who made the museum what it is. Walter Granger describes his adventures collecting fossil dinosaurs in the west; N. C. Nelson tells of his experiences in the gorges of the Yangtze River on the trail of Ancient Man; E. W. Gudger spins some fishing yarns, especially about shark fishing; George H. H. Tate tells about exploring a South American mountain of mystery; H. E. Anthony refers to his adventures with the head hunters of South America; James P. Chapin tells about his five years with cannibals and pygmies of central Africa; Clifford H. Pope gives some of his experiences hunting snakes in China; James L. Clarke describes a thrilling trek of the African lion; Clyde Fisher and Clark Wissler tell about experiences among the present day Indians and the Red Man of yesterday; Robert Cushman Murphy describes a sixteen thousand mile whaling expedition to the Antarctic; Richard Archbold tells about hunting in Mada-

gascar; Barnum Brown tells about his experiences in Patogonia; and Harry C. Raven relates some of his adventures hunting strange animals in Australia.

This is a book that should prove to be among the most widely read books on the science library shelf. In fact, it is doubtful if it would be found often on the shelf.
—C.M.P.

JOHNSON, MARTIN. *Congorilla*. New York: Brewer, Warren and Putnam, 1931. 281 p. $3.50.

"Congorilla" is a record of two years spent by those well-known African explorers, Martin Johnson and his wife, Osa, in the heart of central Africa. The Johnsons did a lot of hunting and shooting—not the usual lion and tiger shooting with guns—but "shooting" that was much more thrilling to the Johnsons—"shooting" with a camera the wild life of central Africa. That they had real thrills may be gathered from a reading of this book or from seeing the sound pictures now being shown.

The Johnsons spent most of their time in the Itura Forest making sound pictures of the pygmy people and in Parc National Albert where they encountered several thousand gorillas. In the latter place they had many thrilling adventures. Three gorillas were captured alive and brought back to this country.

The book is well-written and with many excellent illustrations. It will appeal to all persons who enjoy reading stories of life and adventure in other lands and who, perforce through necessity or through choice, must seek their thrills vicariously.
—C.M.P.

MICHELL-HEDGES, F. A. *Land of Wonder and Fear*. New York: The Century Company, 1931. 265 p. $4.00.

This is a story of the jungle lands of Central America. The author is a member of the Maya Committee of the British Museum and probably knows more about the region of which he writes than any other man. "Land of Wonder and Fear" is a straightforward story of the ruthless jungle and primitive tribes as they really are. Fear, death and laughter go hand in hand. It is not a place the average man would seek for a pleasure jaunt, but is a place of steaming humidity, with vegetation so dense that one is often able to see only a few feet or at most a few yards, where travel is practically impossible, where tree lice, chiggers, scorpions, ants, and mosquitoes abound by the millions and make human life almost impossible. The author vividly describes life and adventures in the jungles in terms that the reader is not likely to soon forget. What an environment for the home of man! With the stifling humidity, torrential downpours, the impenetrable jungle with its teeming, voracious insect life, the deadening monotony—no wonder the white man has not permanently conquered the tropics. That he will do so in the near future does not seem likely.

The book is a well-written, interestingly told story that both young and old will enjoy. Biology students will find it an unusually good portrayal of the effect of environment upon life. —C.M.P.

DITMARS, RAYMOND L. *Strange Animals I Have Known*. New York: Brewer, Warren and Putnam, 1931. 375 p. $3.50.

Dr. Ditmars, who is curator of reptiles and mammals in the New York Bronx Zoo, describes some of his experiences and adventures with animals both in the hunt and at home in the zoo. The book, written in Dr. Ditmars inimitable way, carries you along from one thrilling adventure to another. Sometimes the adventure becomes too real for mental comfort. One is glad to take the thrills vicariously and let Dr. Ditmars describe them. It would be difficult to pick out the most thrilling adventure, but to the reviewer, the most vividly portrayed adventure is the one in which the author describes the capture of two king cobras which had gained the freedom of a small storage room of a New York animal dealer. Some real wild parties are described. The reviewer recommends the book for young and old, teacher, pupil, and the layman.
—C.M.P.

FISHBEIN, MORRIS. *Shattering Health Superstitions*. New York: Horace Liveright, Inc., 1930. 245 p. $2.00.

One tangible aim toward which the science teacher can and should direct his

teaching is the elimination of superstition. Much research has recently been conducted along this line, notably by Dr. Otis W. Caldwell of the Institute of School Experimentation of Teachers College, Columbia University and his associates. 'Shattering Health Superstition" is excellent supplementary material for all biology as well as other teachers of science who are desirous of making available to pupils authoritative discussions regarding health superstitions. The book is recommended to all science teachers and pupils. It is a book that can profitably be read by adolescent and adult alike.

"Shattering Health Superstitions" discusses the origin and truth of many medical superstitions and magic, and explodes many false notions and beliefs regarding health. There are fifty-seven chapters, each devoted to the discussion of some health superstition. A few of the superstitions discussed: Fish is a brain food; It is dangerous to sleep in the moonlight; Whiskey will cure snake-bites; Onion-breath may be removed by drinking milk; Eating meat makes men savage; Medicine to be good must have an odor; A receding chin is a sign of weak character.

The author is widely known as the editor of the *Journal of the American Medical Association,* as editor of *Hygeia,* and as the author of several books relating to health and medicine. —C.M.P.

COTTON, EDWARD H. *Has Science Discovered God?* New York: Thomas Y. Crowell Company, 1931. 366 p. $3.50.

This is a symposium, edited by Mr. Cotton, in which sixteen scientists offer opinions about God and the possibilities of survival after death. They discuss whether the viewpoints of religion and science can be reconciled. Is there a real conflict between the two? Are scientists, such as Millikan, Pupin and others who discuss religion, really scientists who have gone astray as writers like East and Harding would have us believe? Have the scientists found out anything scientifically verifiable about God and Survival? The editor, Mr. Cotton, in summarizing the opinions expressed, states that research has been swinging steadily away from the materialistic, mechanical interpretation of the universe toward the belief on the part of men of science, that the universe has purpose and direction. Whatever one's own personal belief about these matters may be, the opinions expressed by these scientists gives a new slant to our scientific-religious thinking. Churchman, scientist, and layman alike can read these papers with enjoyment.

The scientists contributing to this symposium are: Mather, Millikan, Eddington, Curtis, Conklin, Einstein, Huxley, Patrick, McDougall, Thomson, Pupin, Langdon-Davies, Stetson, Jeans, Lodge and Bird. Thus every field of science is represented, Lodge and Bird representing that very controversial field, psychic research. There is a portrait of each contributor.

—C.M.P.

WELZL, JAN. *Thirty Years in the Golden North.* New York: The Macmillan Company, 1932. 336 p. $2.50.

This is the story of Jan Welzl, a Czech by birth, who has lived for thirty years within the Arctic Circle in New Siberia, north of Siberia. The story is told in a somewhat simple, humorous fashion, and at times the account is somewhat disconnected. Because of his lack of education and ability to read, the account was dictated to two newspaper men who transcribed Welzl's account of his life as literally as possible. The story of his arduous journey to New Siberia, his adventures among the Eskimos, the Eskimo mode of living in this far northland, how he came to be a wealthy trader with headquarters in a commodious cave and finally chief of New Siberia, makes it a book you will long remember. What strange people these Eskimos are—quite unlike those of Greenland as Macmillan describes them or of northern North America as described by Stefansson. During the long Arctic winter the Eskimos live in sealed-up caves, not daring to venture outside except at rare intervals. Woe be to that individual who does, and gets frostbitten! The treatment of cases of frostbite is vividly described. Marriage laws in the usual sense of the term are unknown. Because of undernourishment and lack of medical treatment, the death reate of children and adolescents is very high. An Eskimo who is

forty years old is considered to be very old.

No gangsters and racketeers there! No long, drawn out trials by jury, no coddling of the criminal. Justice is swift, sure and inevitable. When a law violator is caught, the trial seldom lasts over five minutes. If found guilty, there is only one penalty —death. And this penalty is exacted immediately. The less serious penalty is death by hanging, the second is death by shooting and the third death by burning alive. Sometimes the jury is lenient, and the person found guilty is allowed a choice of three methods of suicide—shooting with a revolver, poisoning by means of strychnine, or stabbing with a poisoned knife. The person permitted suicide must choose immediately or else face the firing squad!

Truly half of the world does not know how the other half lives! —C.M.P.

Parker, Bertha M. *An Introductory Course in Science in the Intermediate Grades.* Chicago: The Laboratory Schools of the University of Chicago, 1931. 129 p. $1.25.

Elementary science teachers will find this science course one of the best and most complete courses that has yet appeared. Although the material is that which has been used in the fourth grade of the University Elementary School of the University of Chicago, teachers of the other elementary grades will find many helpful suggestions. Much of the material could be used in other grades. A very complete outline of the exact procedures used in the teaching of this material is given by Miss Parker. The method is illustrated by a detailed analysis of the unit "Rocks and Records of the Earth's History." Outlines of the other units of the course are given. These include: Magnets; Thermometers; Air Pressure; Green Plants as Starch and Sugar Factories; Fish; Snails; Conduction of Heat; Bacteria; Yeasts, and Molds; Bird Migration; and Seeds and Gardening. —C.M.P.

Williams, Henry Smith. *The Biography of Mother Earth.* New York: Robert M. McBride and Company, 1931. 315 p. $5.00.

The reviewer is convinced that most orthodox geologists would not accept the main thesis of this work or even many of its corollaries. It is really an extension of the Wegener hypothesis of Continental Displacement which has found little acceptance among the geologists of this country, although somewhat more warmly received by certain European geologists. This still wider extension of the Wegenerian hypothesis—called by the author the "Geoid—Balance Hypothesis"—is so bizarre and so little supported by factual evidence that probably no geologist, of repute would give it his sanction. However, there is this to be said—many other now commonly accepted theories had little acceptance in the beginning. It does seemingly account for many things at present, or at least partially, unexplainable in science.

The author supposes all land masses to have been originally congregated around the South Pole and to have slowly drifted to their present positions, those of the northern hemisphere having drifted through the torrid zone. Asia, Europe and North America are postulated to have originally been one land mass; similarly South America and Africa. The author maintains that his theory gives a logical explanation for the glaciation in the tropics; for the fact that coal is found near the North Pole, that fauna of the tropics is found in colder northern regions; that fauna and flora of Madagascar and Africa are quite unlike, whereas fauna and flora of now widely separated lands are often quite similar; that the Pacific Ocean is older than the Atlantic; and so on.

The book makes interesting reading, but one must remember that its main thesis is in the realm of conjectural theory rather than accepted hypothesis. —C.M.P.

Newman, Horatio Hackett. *Evolution Yesterday and Today.* Baltimore: The Williams and Wilkins Company, 1932. 171 p. $1.00.

The author in his introduction says, "This little book is written solely for the general reader (and the biology student) who knows nothing or only very little about the subject. I have been advised by the publishers to tell the story of evolution as I should tell it to the first man I happened to meet on the street. . . . I put this matter to an actual test by getting

into conversation with several strangers and eliciting their ideas and quandaries about evolution." Dr. Newman answers the following questions which he found that the average man asks about evolution: (1) What is the matter with the doctrine of creation, anyhow? (2) What is evolution, and why is it superior to the doctrine of creation? (3) Isn't evolution "just a theory"? Why should the average person worry about it? (4) Why can't evolution or no-evolution be settled beyond dispute? (5) If it's proved, why can't scientists convince us? (6) What makes evolution go? (7) Why can't we see it going on to-day? (8) Why can't man be left out of the scheme?

In the opinion of the reviewer, Dr. Newman explains evolution as simply and adequately as it is possible to discuss the subject without the use of a technical vocabulary and discussion quite beyond the man on the street. It is an excellent book with which to introduce the theory of evolution to the young student. The story is simply, yet authoritatively told. The book is another of the Century of Progress science series. —C.M.P.

KETTERING, CHARLES F., and ORTH, ALLEN. *The New Necessity*. Baltimore: The Williams and Wilkins Company, 1932. 124 p. $1.00.

No recent development in science and industry has had profounder effects upon American life, habits, welfare, customs, and manners than has the "carriage without horses" Mother Shipton prophesied in the sixteenth century. The automobile has probably done more to revolutionize social, economic and intellectual life than any mechanical device ever invented. Thirty-five years ago the automobile was a museum curiosity; twenty years ago it was an article of luxury, only for the rich; today it is a necessity.

In this Century of Progress science book, the authors discuss the development of the automobile, the problems connected with its development, and changes that will probably occur in the future. Many interesting incidents are told about this development. Mr. Kettering is Vice-President of the General Motors Corporation and General Director of the Research Laboratories. Mr. Orth is a research engineer in these laboratories. —C.M.P.

BAYNE, JONES, STANHOPE. *Man and Microbes*. Baltimore: The Williams and Wilkins Company, 1932. 128 p. $1.00.

This is another of that excellent Century of Progress series depicting the accomplishments in the various fields of science during the last hundred years. The various chapters discuss microbes as they relate to the soil, air, water, sewage, industry, plants, insects, diseases of animals transmissible to man, diseases of man and civilization. An excellent book for the high school biology shelf. —C.M.P.

ALLEE, WARDER CLYDE. *Animal Life and Social Growth*. Baltimore: The Williams and Wilkins Company, 1932. 159 p. $1.00.

This book on ecology depicts the home life of plants and animals, their environment, their habitats, their communities—what they are and how they came to be as they are. Animals and plants exist in communities, quite dependent upon the interlocking environmental factors. The author, presents a most interesting description of the Indiana sand-dune region, how it came into being, why it is as it is, and why it is inhabited by the living things to be found there. Every plant and animal community has its chain of cause and effect. Man has often been the great disturbing factor in upsetting the balance of nature.

The author describes many situations in the communal life of animals and plants, both lower and higher, that often curiously duplicate human situations.

This Century of Progress book should appeal both to the psychologist and the sociologist as well as the nature lover. —C.M.P.

MALISOFF, WILLIAM MARIAS. *Meet the Sciences*. Baltimore: The Williams and Wilkins Company, 1932. 196 p. $2.50.

This is a panoramic view of the sciences by a scientist-philosopher. The reader is first introduced to the scientist in a general way, his aims and methods, his whims and fallacies, his work and its content. A round-table of the sciences is next presented. Then

each of the major fields of science is presented individually. Finally the author discusses the significance of science in modern life.

Mathematics, logic, physics, chemistry, biology, psychology and sociology are commented upon in turn. The overviews of each of these fields of thought are understandingly, yet compactly given. It is not an eulogy of science or the scientist, but a critical, friendly appraisal. When you have finished reading the book you have a feeling that you have "met the sciences." While the style is most readable and attractive, it is hardly to be classed as a popular book on science but rather as a book for serious laymen. It is recommended to science teachers. —C.M.P.

HORSFALL, R. BRUCE. *Bird and Animal Paintings*. Washington, D.C.: Nature Magazine, 1930. 58 p. $1.50.

These paintings are in natural colors and were made by one of our best known nature painters. Many of the paintings have appeared in "Nature Magazine." Facing the pictures will be found the correct scientific name of the subjects and a résumé of the salient facts in the life history of the bird, mammal, or insect pictured.

Teachers, students, children, parents and nature counselors should find the paintings very valuable. Nowhere else can such an excellent and authentic array of animal pictures be obtained at so low a cost. One hundred and sixty-three paintings, with descriptions, are included. —C.M.P.

METCALF, C. E., and FLINT, W. P. *Fundamentals of Insect Life*. New York: McGraw-Hill Book Company, 1932. 581 p. $4.00.

"Fundamentals of Insect Life" is an authoritative treatise that should prove most useful both to those who are in need of an excellent textbook on insects and to those who need a handy and thoroughly up-to-date reference on that subject. The authors are recognized authorities in this field. The chapter headings are: Insects as Enemies of Man; the Value of Insects to Man; the External Morphology of Insects; the Internal Anatomy and Physiology of Insects; the Mouth Parts of Insects; Development and Metamorphosis; the Place of Insects in the Animal Kingdom; the Important Orders and Families of Insects; Insect Control; Apparatus for Applying Insecticides; Living Environment; the Physicochemical Environment; Insect Behavior.

There are 315 illustrations, a very good bibliography and a most complete index. —C.M.P.

SHERMAN, HENRY C. *Chemistry of Food and Nutrition*. New York: The Macmillan Company, 1932. 614 p. $3.25.

The purpose of this book is "to present the principles of the chemistry of food and nutrition both as an integral part of the study of chemistry and with reference to the food requirements of man and the considerations which should underlie our judgment of the nutritive values of foods and the choice and use of foods for the maintenance and advancement of positive health and vitality."

A vast amount of investigation since the publication of the third edition in 1926 has necessitated the rewriting of the entire book. Some of the older material has been replaced by new, where more positive knowledge has been revealed, and much new material has been added. The tables have been brought up-to-date and are now quite extensive. Some of the most useful tables are placed in the Appendix. In Table 60 (10 pages), we find the composition and fuel values for a large number of edible organic nutrients. For most of these foods two sets of values are given, one set for the food "as purchased" and the other set for the "edible portion." Table 61 gives the mineral composition of these foods and Table 63 gives a summary of what is known to date regarding various foods as sources of vitamins.

For the benefit of those who may wish to pursue the subject further, the author gives a rather extensive bibliography at the end of each chapter. Many of these references are to works published in 1931 and in the main body of the text are references to the literature for the current year.

Chapters are devoted to a discussion of the composition and the chemistry of the carbohydrates, fats and proteins, to the occurrence of these materials in various

foodstuffs, to the process of digestion and the part played by enzymes, and to the fate of the foodstuffs in metabolism. Similar chapters are devoted to the discussion of the part played in nutrition by the inorganic foodstuffs, particularly by calcium, phosphorus, iron, copper, and iodine.

It is pointed out that not all foodstuffs containing a given food material are of equal value. The body requires a certain amount of the material, say calcium, and the diet must be so adjusted that sufficient of its calcium content will be retained to meet the needs of the body. The excess of calcium in the diet over that which the body is expected to retain is determined by the nature of the foodstuff. Thus, for example, if two diets are used by a growing child, one containing a daily ration of one quart of milk or milk products, and the second a pint of milk and an amount of other foodstuffs to equal in calcium content the other pint of milk, it is found that a larger percentage of the total calcium content is retained from the first diet than from the second.

An account is also given of the way in which the body functions to preserve an optimal concentration of a given material and of the changes which occur to counteract an excess or deficiency of the material in the diet. A deficiency of a given type of food is usually of far greater consequence in its effects upon health than is an excess of this foodstuff.

Chapters are devoted to each of the known vitamins. Their chemical constitution is discussed and accounts are given as to the effects of each on nutrition. A very readable outline is given of the various scientific experiments by means of which we have obtained our present knowledge of the vitamins. This material is decidedly helpful in enabling one to use sound judgment respecting the claims advanced in the public press by those promoting the sale of certain natural or proccessed foodstuffs.

In the chapter on vitamin D (the antirachitic vitamin), for example, the author concludes his survey by remarking that the concentration of attention upon the enrichment of foods in vitamin D by means of artificial irradiation has led most people to overlook the fact that many natural foods contain significant amounts of vitamin D.

In the chapter on dietary standards the question is put whether a normal appetite does not indicate, as well as can any dietary standard, the amount of food which is desirable for an individual in any given circumstances. Sherman shows that the normal appetite is a most unreliable guide, even when by "amount of food" we mean only its energy value, and that the other chief factors in nutrition, proteins, mineral content, and vitamins are almost completely neglected.

The concluding chapter on the problem of the best use of food should provoke serious consideration on the part of those interested in improving community health. Many have thought that the development of an adequate diet would end their difficulties. The author shows that the use of what he calls an optimal diet can be very influential in promoting better health, in extending the span of life, and in other ways. He points out that there is a real distinction to be recognized and a wide zone to be explored between adequate and optimal nutrition.

Teachers and students of science education will welcome this timely and authoritative contribution. —S.R.P.

DuPuy, William Atherton. *Wonders of the Plant World.* Boston: D. C. Heath and Company, 1931. 196 p. $0.88.

This is the latest addition to a series of books by the well-known nature writer DuPuy. In this book he gives a few peeps into the mysterious vegetable world. Each of the ninety-five brief chapters begins with the phrase "Isn't it odd that . . ." and the reader wants to know immediately what is odd and why. The author reveals many interesting things not commonly known about plants and animals. The book is a suitable supplementary reader for junior high school and senior high school students. —C.M.P.

Klopp, William J. *The Relative Merits of Three Methods of Teaching General Science in the High School.* Chicago: The Central Association of Science and

Mathematics Teachers, Inc., 1930. 82 p. $1.00.

This is a doctor's dissertation, the purpose of the study, being to determine the relative merits of three methods of teaching general science in the high school, viz., the textbook, the lecture, and the telling—demonstration methods. The experimental group consisted of twenty-two second semester classes in general science in six secondary schools, located chiefly in Los Angeles. The average number of pupils in each class was 30, with an average age of 15.2 years. Units were selected from each of the fields: botony, zoölogy, and physics. (Snyder's General Science). The demonstration method was found to be superior, followed by the lecture method, with the textbook method last. A questionnaire revealed that the pupils also preferred these methods in the order in which progress—test scores showed them to be superior. —C.M.P.

DAVIS, WATSON. *Science Today*. New York: Harcourt, Brace and Company, 1931. 310 p. $2.50.

This is a series of forty-seven brief, condensed papers originally presented as radio talks over the Columbia Broadcasting System under the auspices of *Science Service*, Washington, D.C. Many of these talks have been published in *Scientific Monthly* and the *Science News Letter*. The contributions, each by an eminent man of science, depict newest discoveries and achievements in the various fields of science. Among the contributors are: Abbot, Mitchell, Stetson, Olivier, Lane, Mather, Bowie, Heck, Bragg, Compton, Richtmeyer, Humphreys, Wheeler, Lutz, Mann, Cole, Morley, Merriam, Dunlap, Carlson, Davis, and others. —C.M.P.

RAMUS, CARL. *Behind the Scenes with Ourselves*. New York: The Century Company, 1931. 443 p. $3.00.

Ramus agrees emphatically with Shakespeare that the world is a stage and that we are actors consciously or unconsciously playing a part—a part usually foreign to our real nature. Why all this play—acting, shams, make-believes, these passing shows, styles and conventional attitudes? In this book Dr. Ramus gives the underlying psychological causes that motivate snobs, gossipers, dreamers, censors, social and sexual misfits, criminals, and neurotics. He explains our attitude toward death, funerals, flowers, and ceremonies; our standards of propriety, our deference to conventionalities, our "views" on marriage and divorce, our political "opinions," our religious "convictions," and so on.

The discussion is interspered with frequent case illustrations. Many times the reader will find himself saying, "I know a person just like that!" —C.M.P.

KEELOR, KATHARINE. *Working with Electricity*. New York: The Macmillan Company, 1931. 111 p. $1.75.

"Working with Electricity" describes some of the class-room experiences of a group of ten-year-old boys and girls in the Lincoln School of Teachers College. Many elementary teachers, including some elementary science and nature study teachers, have a notion that anything pertaining to the field of physics, and more especially electricity, is beyond the ability and understanding of elementary pupils. Much evidence is at hand to prove that this notion is fallacious. Elementary children can and do understand many of the natural phenomena in the field of the physical sciences. This book is partial proof that even some understanding electricity is not beyond eight and ten year olds.

The books describes the work carried out by Miss Keelor. Chapter headings are: Lights; Bells and Magnets; Messages by Electricity; and Messages before Electricity and Now. Many experiments are described and illustrated. The following are a few: how electricity makes light; connecting batteries in series and parallel; closed circuits; doorbell; magnets and magnetism; and electromagnets. The appendix lists the supplies needed for the work described in the book. This book is recommended to the elementary-science-teacher who would like to do some simple experiments in electricity. —C.M.P.

MILLER, FRANCIS TREVELYON. *Thomas A. Edison: Benefactor of Mankind*. Philadelphia: The John C. Winston Company, 1931. 320 p. $1.50.

It is probably true that too little attention has been and is being paid in our

science classes to the biographies of eminent men of science. Here is an excellent opportunity for giving training, vicariously, in the use of the scientific method and in educational and vocational guidance. This excellent book admirably serves these purposes. The author, Mr. Miller, knew Mr. Edison intimately and with his unusual ability as a writer he has produced a story of the life of Edison that will likely be read by thousands of boys and girls for many years to come. This is a book that classes in general science, physics, and chemistry alike will find useful as supplementary reading material. There are many excellent illustrations. —C.M.P.

WELLS, MORRIS MILLER. *The Collection and Preservation of Animal Forms.* Chicago: General Biological Supply House, 1932. 72 p. $1.00.

Biology teachers will find this one of the most complete and up-to-date manuals that has been published on the collection and preservation of animal forms. Each division of the animal kingdom is treated quite completely, yet so simply that biology teachers even with little or no experience will find it quite as helpful as those having more experience in collecting and preserving animals. The appendix discusses several basic killing and preserving solutions.

The author, Dr. Wells, who recently died, was formerly teacher of zoölogy in the University of Chicago and later served as president of the General Biological Supply House. —C.M.P.

ASTELL, LOUIS A., and ODELL, CHARLES W. *High School Science Clubs.* Urbana: College of Education, University of Illinois, Bureau of Educational Research, Bulletin No. 60, 1932. 77 p. $0.50.

This consists of a study of science clubs in Illinois High Schools based upon a questionnaire sent to all science teachers in that state. Included are analyses of purposes, rules and regulations and activities of the clubs found. Chapter four consists of criticisms and suggestions concerning the operation of the clubs. An annotated bibliography of 403 titles completes the bulletin. The bibliography includes articles from magazines giving detailed directions for specific club activities and general references upon extra-curricular activities and the theoretical relationship of the extra-curricular program to secondary education. —R.K.W.

ZYVE, D. L. *Stanford Scientific Aptitude Test.* Stanford University, California: Stanford University Press, 1930. $0.75.

This test is designed for college students. No time limit is set for the test. The test is divided into exercises to test: Experimental Bent; Clarity of Definition; Suspended versus Snap Judgment; Reasoning; Inconsistencies; Fallacies; Induction, Deduction, and Generalization; Caution and Thoroughness; Discrimination of Values in Selecting and Arranging Experimental Data; Accuracy of Interpretation; and Accuracy of Observation. A manual of directions, scoring key and explanatory booklet accompany the test. —C.M.P.

TOMLIN, FRANK E. *The Best Thing To Do.* Stanford University, California: Stanford University Press, 1931.

This test is designed for use in grades four to eight. Norms have been established for each of these grades. There are two forms of the test: Form A, and Form B. Key and Manual accompany test.

—C.M.P.

BERNREITER, ROBERT G. *The Personality Inventory.* Stanford University California: Stanford University Press, 1931. $0.25.

This test, consisting of one hundred and twenty-five items, is designed to measure the following traits: neurotic tendency; self-sufficiency; introversion—extroversion; and dominance—submission. Norms, Key and Manual accompany test.

—C.M.P.

WRENN, C. GILBERT. *Practical Study Aids.* Stanford University, California: Stanford University Press, 1931. 16 p.

This compact, yet very practical little booklet is divided into five parts: budgeting your time; improving your reading efficiency; increasing your ability to con-

centrate; taking notes; and preparing for an examination. The booklet is recommended to college and high-school students as well as teachers emphasizing "study habits" in their courses.

—C.M.P.

RIDGLEY, DOUGLAS C., and KOEPPE, CLARENCE E. *A College Workbook in Weather and Climate*. Bloomington, Illinois: McKnight and McKnight, 1930. 128 p. $0.60.

College teachers of geography, physical geography and survey courses in science will find some very useful suggestions in this workbook—one of the first to appear in this field and one of the few in any science field at the college level. References, exercises, and problems for future study are included. —C.M.P.

SYMPOSIUM. *The Sky Book*. Ithaca, New York: The Slingerland-Comstock Company, 1931. $0.75.

"The Sky Book" is a field and camp notebook. The notebook is divided into eight parts "Star Guide Constellations" is written by Gilbert H. Trafton; "Star Maps" by Anna Botsford Cornstock; 'The Solar System" by Theodosia Hadley and Helen Barton; and "How to Know Clouds" by Paul B. Mann. The notebook is pocket size and contains much useful information about the stars, the constellations month by month, the planets and clouds. —C.M.P.

Chicago Chemistry Teachers. *Chemistry Manual*. Chicago: Lyons and Carnahan, 1931. 202 p.

This chemistry laboratory manual was prepared by the Chemistry Curriculum Committee and approved by the Chicago Chemistry Teachers Association. The manual is divided into two parts—one part for each semester. There are 35 experiments listed in the first semester manual and 32 experiments for the second semester. The manuals are of the loose-leaf type and do not require a separate notebook. The experiments are well selected and should give a rather complete year's laboratory course. —C.M.P.

CHICAGO ZOÖLOGY TEACHERS. *Zoölogy Manual*. Chicago: Lyons and Carnahan, 1931. 94 p.

This laboratory manual was prepared by the Zoölogy Curriculum Committee of the Bureau of Curriculum of the Chicago Schools. Separate laboratory manuals have been prepared for the fall semester and the spring semester. The manuals are of the loose-leaf type and the leaflet for each experiment may be removed from the manual.

The fall manual contains five units and the spring manual eight units. Each unit is divided into a series of problems. A series of excellent references and questions are included. Zoölogy teachers will welcome this comprehensive manual while biology teachers will find in it many useful suggestions. —C.M.P.

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